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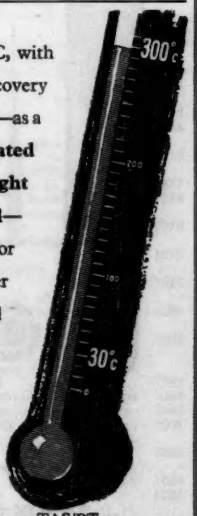

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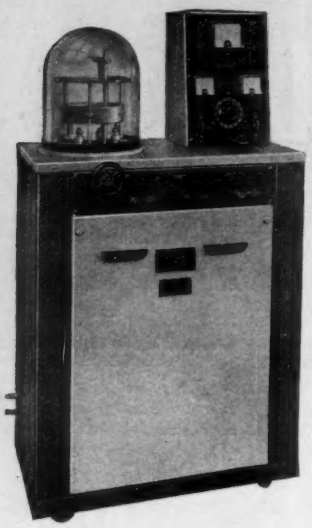

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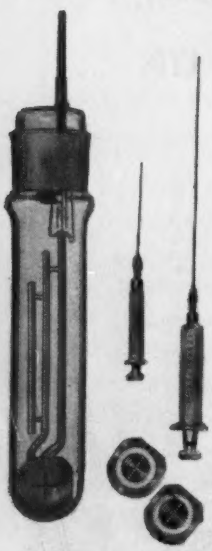

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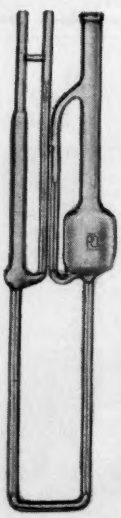

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INDUSTRIAL HEALTH PROBLEMS IN THE USE OF NUCLEAR ENERGY

THE second of the Committees of Inquiry set up under the chairmanship of Sir Alexander Fleck following the accident to Windscale Pile No. 1 on October 10, 1957, was "to review the organization within the Atomic Energy Authority as a whole for control of health and safety and to make recommendations"; a survey of the report appears on p. 1043 of this issue. The Committee appointed to examine the organization and staffing of parts of the Authority has already reported and attributed the accident primarily to an insufficiency of senior technical staff in the Operations Branch. The strengthening of this Branch was regarded as a first essential even if it involved some curtailment of developments elsewhere. Understaffing is also the primary trouble revealed by the examination of the Authority's organization for control of health and safety*. The Committee is satisfied there are no fundamental weaknesses, but is concerned to note that the acute shortage of expert health and safety staff means that the planned organization is seriously under strength in the higher posts. The health and safety organization is called upon to perform a wide variety of duties, both internally and externally, many of which require expert qualifications in more than one of the fields of medicine, radiology, health, physics, mathematics, nuclear physics or nuclear engineering. The review revealed an acute shortage of people possessing the requisite qualifications; throughout the Authority there were only about ninety people possessing honours degrees or equivalent qualifications who were engaged full-time on the control of health and safety.

Nor is it simply that these people are seriously over-burdened, with the result that the safety officers at Windscale had had little exact guidance about the amount of radioactivity that could safely be allowed to accumulate in the area. With the development of the nuclear power programme and the increasing use of radioactive materials in medicine, agriculture and many parts of industry, the demand for specialist health and safety staff will increase still further. That much is attested by the annual report† of the Chief Inspector of Factories for 1956 (see p. 1043 of this issue), which followed that of the Fleck Committee. Not only is the question of safety in nuclear power stations one of the four main topics which Sir George Barnett selects for discussion in this, his last, report, but also elsewhere in the report the use of ionizing radiations in industry is discussed at some length. What the Fleck Committee urges as to the desirability of making the field of health and safety provide an attractive career for those able to acquire the necessary expert knowledge finds ample corroboration in Sir George Barnett's report.

For the Authority this would involve, the Committee points out, permitting greater flexibility in salaries, particularly for the specialist medical staff needed to head the integrated health and safety organizations in the works of the Industrial Group. More important still, the Fleck Committee considers that the Authority, as the vanguard of the nation's effort in nuclear energy, should assume responsibility for building up the supply of expert health and safety officers at all levels, from managers to the technicians who will be required in ever-increasing numbers by the electricity authorities and industry as well as by the Authority itself. The main instruction in the United Kingdom on the health and safety problems of nuclear energy has hitherto been given by the Authority as part of its courses in the Reactor and Isotope Schools at Harwell and the Reactor Operations School attached to Calder Hall. Factory inspectors are now taking short courses at Harwell to help them in inspecting industrial establishments where radioisotopes are in use.

This has covered only a small part of the field, and the Fleck Committee holds that more comprehensive instruction is needed. In view of the urgent need and the impact of the shortage on the Authority, the Committee recommends that the Authority should take the lead in this matter, by establishing a national training centre for health physics and nuclear safety staff (under the administration and general supervision of its Research Group) where courses should be graduated to suit all levels and cover not only problems of protection against radiation hazards, but also the health and safety aspects of the use of isotopes in medicine, agriculture and industry. In the medical field, the Authority should be prepared to recruit and to finance the specialized training of candidates who will be required for future management posts, and the Committee visualizes this specialized training as being worthy of recognition as a new professional qualification. Moreover, the Authority should also recruit and give training on the job to the medical staff required to provide the new type of medical service, as well as recruit and train a cadre of health physicists and nuclear safety experts commensurate with the future needs of the nation as a whole. It is recommended that Government departments should be directed to ensure that appropriate training in radiological problems is given to the public services and industries for which they are responsible

The Committee's specific recommendations regarding the Authority's internal responsibilities and organization are summarized elsewhere (see p. 1043 of this issue); but before considering the implications of the assumption by the Authority of such national responsibilities for leadership, the background against

* Atomic Energy Office. Report of the Committee appointed by the Prime Minister to examine the Organisation for Control of Health and Safety in the United Kingdom Atomic Energy Authority. Pp. 28. (Cmnd. 342.) (London: H.M. Stationery Office, 1958.) 1s. 3d. net.

† Ministry of Labour and National Service. Annual Report of the Chief Inspector of Factories for the year 1956. Pp. 195. (Cmnd. 329.) (London: H.M. Stationery Office, 1958.) 9s. 6d. net.

which these recommendations are made must be appreciated. The Committee was particularly conscious that the accident at Windscale brought to the surface the latent public anxiety about the hazards of nuclear energy. Now that the nation is committed to a large nuclear-power programme, the Committee holds, and rightly, that it is of the first importance that the hazards of nuclear energy should neither be exaggerated nor minimized in the public mind. The Authority has sought to err on the side of caution and, within the limits of existing knowledge, takes no chances. The Health and Safety Organization plays a major part in the Authority's affairs, and the Committee is satisfied that in general the Authority's policy has hitherto been governed by the considerations that operating procedures and codes of practice must not risk endangering workers or the public and, within the limits of human ingenuity, must be proof against human failure.

Nevertheless, the Committee became aware that besides making good the deficiencies in the Authority's organization, there is urgent need to clarify the relations between the many Government departments concerned with health and safety in the field of nuclear energy and to strengthen the co-ordination between them. That is the reason for the recommendation that the Atomic Energy Authority should be built up to enable it to play the leading part and ensure that all necessary action is initiated in good time. Since the ultimate responsibility for assuring safety in relation to nuclear energy must be borne by the Government, it is of vital importance, the Committee urges, that this major improvement in organization should be made. Linked with it, of course, is the question of public confidence, and while the Committee endorses the arrangements for local liaison which the Authority has initiated, it recognizes that special care is required in public relations; and it therefore recommends that the Authority should review present procedures for publishing information about accidents, with the view of giving a prompt account of such occurrences in as much detail as may be appropriate. Moreover, apart from its bearing on health and safety, public confidence could be a decisive factor in the smooth implementation of the nuclear power programme.

The three most important implications of these recommendations are in respect of staff, of finance and of time, and all three are appropriately considered in the context of Sir George Barnett's valedictory report as chief inspector of factories. It will be recalled that even before the publication in October 1956 of the report on the staffing and organization of the factory inspectorate, the Minister of Labour had announced his decision to treble the size of the Engineering and Chemical Branch of the inspectorate, and to increase that of the general inspectorate by 26 posts. Nevertheless, at the end of 1956 Sir George Barnett reports that only 375 out of an authorized 439 posts were filled, and 25 inspectors were lost during the year, 17 by resignation. On February 5 the Minister of Labour, Mr. Iain MacLeod, said there were still 33 vacancies, though the number of inspectors had risen to 394 with 15 awaiting appointment, and there had been only 9 resignations in 1957. The present recruitment situation in the general inspectorate was not unsatisfactory, and it was hoped to fill the three vacancies in the Medical Branch from an open competition.

This position, as the White Paper on the Factory Inspectorate fully recognized, is related to the national shortage of scientists and technologists. Of this the Fleck Committee was no less cognisant; but none the less its argument that an adequate proportion of that scarce and limited man-power must be directed to this field, even at the cost of curtailment elsewhere, cannot be gainsaid. Moreover, in stressing the need for making the conditions and opportunities of service more attractive, it is again in harmony with the findings of the White Paper, and these steps could well further that greater esteem and understanding of the factory inspectorate's work which is so important for efficiency and recruitment. Taking a long view, that report was concerned not to advance unreasonable claims for expanding or even maintaining the factory inspectorate. On the contrary, it conceded the possibility, and even the probability, that with continuing improvements in the design and operation of factories and industrial processes, the cumulative effect of the work of the inspectorate would permit a substantial reduction in the resources of man-power devoted to factory inspection.

That almost certainly is the way in which the most efficient use of highly trained man-power is to be achieved and if, by emphasizing the opportunities for scientific work which careers in industrial health and safety offer, and ensuring that the conditions of service are appropriate, we can attract sufficient recruits of high ability, the purpose of industrial health and safety should itself be more effectively served than by reliance mainly or solely upon the inspectorate. For many years to come, the need for close co-operation will remain and there will be much, possibly even more than to-day, for the inspectorate to do; but it is in harmony with the whole trend of the Chief Inspector's report that such work should be done primarily and to the maximum degree from within industry.

That is only part of the picture. The Fleck Committee was not solely concerned with the supply of specialists of high qualifications and ability; it recognized the need for expert health and safety staff at all levels—from managers to technicians. There is a significant section in the chapter on accident prevention in Sir George Barnett's report which bears on this. In many sections of the Factories Acts and in some codes of special regulations made under the Acts, an employer is required to have certain duties carried out by a "competent person" or a "responsible person". These duties are very varied and include, among others, the detailed technical inspection, examination or testing of boilers and autoclaves, lifting machines and appliances, scaffolds, breathing apparatus and ventilating plant. This work plays a most important part in ensuring the safety and health of workers, but in general receives little public notice unless something goes wrong.

There are two points to be emphasized here. First, the adequacy and effectiveness of such work go far to determine both the effectiveness of the control exercised by the more highly qualified health and safety officers, and also the number of such officers required. In other words, it determines the most efficient and economical use of the most highly trained categories of scientists and technologists. Secondly, those carrying out such duties are themselves essentially specialists. Indeed, at one extreme they may require to be scientists or technologists possessing fundamental theoretical knowledge combined with sound practical experience of the kind of plant to be examined; and while other work may require less technical knowledge, good experience and sound judgment are invariably required.

We are thus once again touching an important facet of the problem of technical education, and it is obvious that if the full benefit of the recommendations of the Fleck Committee in the comparatively limited field of nuclear energy are to be realized, due attention must be given to the extension and improvement of technical education, as the Chief Inspector himself notes in a specific reference to the technical colleges. Where that reaches a sufficient standard, it is clear from the Chief Inspector's current report there is little cause of complaint, for example, in chemical works. Nevertheless, as the report insists, the work of the "competent person", however high his qualifications, must be integrated with that of the accident prevention organization as a whole; and meticulous care and close and harmonious relations between the different works departments concerned, the safety organization and the inspectorate are essential.

That, of course, means finance as well as manpower, and it is important to emphasize, at a time when the Government is pre-occupied with economy, that industrial health and safety involve expenditure. But wise investment in this way brings a return many times over in industrial efficiency, altogether apart from the elimination of human suffering and loss of life. A programme such as the Fleck Committee has outlined will involve the expenditure of considerable sums, which will have to be found, even at the cost of curtailing expenditure elsewhere.

Thirdly, there is the question of timing. The Fleck Committee rightly insists that action is urgently needed and cannot wisely or safely be postponed. The health and safety specialists, the safety organization and codes and the supporting technicians must be trained in advance, so that they are ready to take up their duties as soon as they are needed. Preparation cannot be deferred just because the new power stations are only being planned or under construction, still less because a time of national economy is inconvenient for incurring such expansion in expenditure. There could be no plainer warning to both major political parties to seek to agree on what sacrifices in non-essentials—even in the social services—it may be necessary to recommend to the country, to ensure that the health and safety of the workers concerned and of the nation as a whole are fully secured.

EVOLUTION AND ORGANIZATION

The Strategy of the Genes

A Discussion of Some Aspects of Theoretical Biology. By Prof. C. H. Waddington. With an Appendix by Dr. H. Kacser. Pp. ix+262. (London: George Allen and Unwin, Ltd., 1957.) 28*s.* net.

AMONG the more important of the advances that are at last really bringing us to grips with the relation between genetics and evolution is Waddington's experimental demonstration of the genetic assimilation of acquired characters, an apparently 'Lamarckian' phenomenon that needs no 'Lamarckian' explanation. In this book Waddington discusses the concepts that led to and arise from such experiments and considers some of their consequences. There is also a discussion by Kacser of models based on chemical kinetics that have relevant properties.

The most essential concept is that the processes of development are canalized so that the effects of disturbances are not random, but tend to be buffered or damped or otherwise compensated for by consequential effects that leave the resulting organisms 'organized'. From this basis, through a discussion of "the cybernetics of development" Waddington develops his model, the "epigenetic landscape", which pictures the probabilities that development will follow particular paths to given end-results. The contours of the landscape are determined by the genotype, and the process of development is represented by a ball rolling down the valleys.

This model provides a picture of the organization of developmental processes that aids discussion of the different properties of epigenetic systems and classification of selection "in relation to the type of effect which it produces". Canalized development may involve narrow valleys, or broad U-shaped valleys that permit minor modification by environmental or genetic variation. It may be flexible, alternative valleys being available into which the ball may be pushed, perhaps over a threshold, by environmental switches, and which lead the organism to different adapted forms; and it may be "noisy" in the sense that random sources of variation are inadequately buffered (represented by imperfections of the ball's surface). Selection in consequence may be not only progressive or directional, but also it may be stabilizing if it increases the canalization of the valleys (as opposed to normalizing if it reduces the variety of genotypes), and it may operate against "noise" so that homologous organs come to differ less. It may also be "disruptive" (Mather), though Waddington thinks, surely erroneously, that "this can be adequately regarded as a sub-type of the more usual unidirectional selection".

Such a model of developmental organization helps greatly the understanding of the effects we may expect different modes of selection to have. It is especially helpful in illustrating the way in which an environmental switch that pushes development over a threshold into an alternative path may aid selection of those genotypes which make the threshold lowest. Selection may thus produce a population in which the new path may be canalized by further selection until it becomes the norm even in the absence of the environmental switch. Waddington's discussions of these topics should interest all and stimulate many biologists.

But the model has its limitations. Waddington is aware of this; but nevertheless seems to push it too far in some respects. The model to some extent divorces genotype from environment and genes from

other genes in a new way. Thus the landscape (Fig. 5) has its form determined by genotype, and an acquired character results if an environmental factor pushes the ball over a threshold into a valley not normally followed. "Organic selection" can then (Fig. 30) select a mutant allele that replaces the environmental switch, or "genetic assimilation" can change the landscape so that the threshold is removed. This seems to involve a distinction between landscape genes, ball-pushing genes and ball-smoothness genes (responsible for reducing developmental noise), though they are all landscape genes by definition. Thus noise genes "probably play relatively little part in evolution", though it seems impossible to see any difference in principle between them and canalizing genes which do.

It seems to be this tendency to push the model too far that leads Waddington to wonder speculatively at the origin of the ball-pushing mutants in his experiments, and he tentatively speculates whether the biochemical situation responsible for the landscape and altered by the environmental switch may not itself be responsible for the mutations. Here Waddington comes full circle and wonders whether the 'Lamarckian' phenomenon that he has demonstrated to need no 'Lamarckian' explanation does not need a 'Lamarckian' explanation after all. Now we must agree that mutation is often termed random very loosely, and that the class of viable mutations is clearly restricted to those to which the rest of the genotype is preadapted in the environment(s) in which the organisms must survive; and we must also keep an open mind concerning the possibility of genuine directed mutation. But it seems inappropriate to speculate whether directed mutation may be involved in particular experiments without first eliminating other more plausible hypotheses. Even if it were necessary to suppose that the mutant genes in Waddington's experimental populations have been produced by his experimental conditions, there is more than one plausible mechanism that does not involve directed mutation. In particular there is evidence that the stability of meiosis is easily disturbed, and therefore it is possible that selection may change the frequency and spectrum of recombination and thus increase the likelihood that particular recombinations with relevant effects may arise. Waddington admits that rare recombination and mutation may be hard to distinguish, but does not seem to see that this does not make the distinction any the less important.

This leads to the major criticism that must be made of this book. Throughout, the part played by linkage in maintaining the organization of development is belittled or ignored (as a consequence of which scant recognition is given to Mather's work). But in the face of evidence that genes of major effect are themselves linked complexes and that recombination can of itself give lethal effects, especially when the recombining chromosomes come from unrelated populations, it is impossible to believe that the organization of development does not involve the organization of genetic material into linked groups. To Waddington, the role of linkage is to be viewed in terms of the tactics of the genes; their strategy involves their part in the organization of development. But this is because he clearly regards the egg as the hen's means of making another hen, for he is discussing (preface) "biological organization and the developmental processes that *bring it into being*" (my italics). But "the hen is the egg's means of making another egg" is a re-statement of the same truth. More attention to the biological organization at the *beginning* of the developmental time-scale would improve this illuminating and stimulating discussion of the organized developmental processes that Waddington calls the epigenetic system. J. M. Thoday

THE WEALTH OF INDIA

The Wealth of India

A Dictionary of Indian Raw Materials and Industrial Products. Raw Materials, Vol. 4: F–G (with Index). Pp. xxviii+287+13 plates+viii. (New Delhi: Council of Scientific and Industrial Research, 1956.) n.p.

THE fourth volume of "The Wealth of India" closely resembles its predecessors, that is to say, it is a scholarly production overflowing with up-to-date information. Unfortunately, much to the regret of the compilers, circumstances over which they have no control have resulted in an interval of nearly four years between the dates of issue of Vol. 3 and 4, and even now it has not been possible to include the obviously important article on "Fish and Fisheries". It is pleasing to note that those responsible are taking all possible steps to expedite the completion of the series.

It is difficult to compile information; it is still more difficult to decide what to leave out in order to satisfy the average reader who requires his information to be as concise as possible, especially when economic subjects are in question. The advisory board for the present publication realized this fully, and in 1943, before work was started, drew up a number of admirable directions for the editorial board. It is regrettable to find that many of these have now been ignored. The maximum length of a major contribution was not to exceed twenty-five pages of the book as now printed, and yet "Gossypium" covers eighty-two. This article, with its three beautiful coloured plates, 44 figures and 64 tables, occupies nearly one-third of the whole volume, and although difficult to compress, contains much which could be omitted with advantage. Photographs of 158 cotton samples distributed through 63 peges so that comparison is hindered seem unduly numerous; the table showing the properties of these fibres is much more informative. On the other hand, two excellent maps indicate so clearly the acreage and production of cotton and the spread of improved types that the corresponding tables appear unnecessary. Many of the tables are of interest only to specialists who might prefer to consult the original sources, reference to which is invariably given. Much space is taken up by detailed statistics for each main political division of India. This seems inappropriate in view of the almost complete absence of correlation between cotton growing and State boundaries. One table gives a number of analyses of black cotton soils differing widely in composition, but no indication of their value for growing cotton. The large amount of matter of secondary importance tends to obscure much that is interesting and informative, and it is suggested that in future all major articles should be preceded by a table of contents.

There is some tendency to give over-elaborate descriptions of products not well established in India although common in other countries. For example,

the comprehensive article on soybean, admirably written, seems far more detailed than is required to show the importance of this commodity and the desirability of extending its cultivation in India. Many of the analyses given refer to material of foreign or unknown origin and are of little value, whereas comparative figures for Indian and foreign products, such as those given for fennel and tallow, often reveal striking and important differences. Production figures for cotton in tons, bales, maunds and candies do not conduce to clarity. Lastly, a few of the illustrations are of poor quality in marked contrast to the majority, and do nothing to elucidate the text.

The above remarks are not intended to disparage, but to convey a few impressions of an important and valuable book. To increase its value still more it is hoped that the practice of issuing provisional subject indexes will be continued and that they will be in even greater detail than that attached to Vol. 3.

H. E. WATSON

EAST AFRICAN MOUNTAIN FLORA

Afroalpine Vascular Plants

A Taxonomic Revision. By Olov Hedberg. (*Symbolae Botanicae Upsalienses* 15 : 1.) Pp. 411+12 plates. (Uppsala : A.-B. Lundequistska Bokhandeln, 1957.) 40 Kr.

SINCE the extraordinary vegetation of the African equatorial mountains was revealed during the latter part of last century, the problems of its relationships and the reasons for its occurrence have exercised the minds of botanists. In this region, where the chill of a rarified atmosphere tempers the heat of a tropical sun, and where there is little variation throughout the year in the length of day and night and in the range of temperature, the flora is of exceptional interest. Nowhere in the world are alpine landscapes so weirdly beautiful as on these mountains of East Africa. Each mountain group in its higher zones has an assemblage of species the nearest relatives of which do not occur at lower altitudes on the same mountain, but in the corresponding zones of neighbouring though totally isolated mountains. In the alpine regions there is some degree of endemism, but it is the vicarious species of genera such as *Lobelia*, *Senecio*, *Helichrysum* and *Alchemilla* that pose interesting problems in regard to common ancestry and comparatively rapid rates of evolutionary diversification on the various mountains. On the other hand, there are species which are common to some of these mountains and the north temperate region the isolation of which has not produced any significant morphological change.

The first attempt to consolidate and summarize knowledge on the flora of the tropical African mountains was Engler's work "Über die Hochgebirgsflora des tropischen Afrikas", which was published in 1892. Engler's material was very sparse and almost entirely confined to collections made on Kilimanjaro, the other mountain groups at that time being virtually unexplored botanically. In the present century there have been a number of well-organized expeditions to all the high mountains of East Africa and splendid collections have accumulated, especially at the British Museum, Kew and botanical institutions in Sweden. There was urgent need for a thorough taxonomic study of this unique dispersed flora and Dr. Hedberg's revision is a massive and authoritative *exposé* of the subject. His survey is rather arbitrarily confined to the species which occur in the alpine belt immediately above the heath forest. This has the merit of giving some definite topographical and ecological limits to the work and bringing the treatment of the material within manageable scope, though, with the exclusion of the ericaceous belt, and also the bamboo zone and the mountain forest, many of the most interesting elements in the flora are eliminated. The closeness of the links between the mountains is thus more obscure and the interesting intra-continental relationships with floras of West Africa, the Cape and the Mediterranean basin are unrecorded.

In his taxonomic analysis Dr. Hedberg has taken a tolerant and sensible view of the various taxa, particularly in his conclusions on the species which have a wide distribution in the north temperate zone. He has laid stress on resemblances rather than on differences and has thus resisted the modern tendency to recognize critical units.

The work is well produced with a judicious number of text figures and a supplement of habitat photographs of certain species. Altogether this account of the Afroalpine vegetation is one of the most significant and meritorious recent contributions to the study of the African flora.

G. TAYLOR

ECONOMIC THEORY

The Theory of General Static Equilibrium

By Prof. Eraldo Fossati. Edited by Prof. G. L. S. Shackle. Pp. xvi+247. (Oxford : Basil Blackwell, 1957.) 30*s*. net.

THE lectures on economics which Prof. E. Fossati gave when he was at the University of Trieste have been known at second hand by many economists in Britain, and by the few proficient in Italian in more detail through his "Elementi di economia razionale", first published in 1946. The volume now reviewed is an English version of the fourth edition (1954) of Prof. Fossati's text. It is not simply a translation, but rather a new edition by an outstanding English theoretical economist. Prof. G. L. S. Shackle explains in his foreword that he found the text in need of "re-expression in the forms of thought with which the English-speaking economist works". Consequently "this English version has been entirely written out in my own hand in phrases which are mostly of my own choosing".

The student of economic principles in Britain, brought up in the Marshallian tradition, tends to acquire a knack for improvization, to assume away the less immediately relevant interdependencies in his problem and to concentrate on those analyses which involve the view of the problem through time. He usually lacks the guidance which can be provided by Pareto's unifying concept of general static equilibrium. As Prof. Shackle points out, it is not generally possible to get him to read Pareto's "Manuel". The present version of a text by a brilliant successor and expositor of Pareto should redress the balance. It will certainly be welcomed by all teachers of courses in general economic principles and it should make a most valuable, if subsidiary, text to put in the hands of students.

The scope of the book is not quite as limited as the title might indicate. One of Prof. Fossati's conten-

tions is that the theory of general static equilibrium is not only of importance in itself but also serves as "a powerful apparatus for dynamic analysis . . . by offering deep insight into the reaction of representative consumers and entrepreneurs to given situations . . . and through the process of model construction, it paves the way to econometric research" (author's preface, p. xii). There are chapters towards the end of the book, simple and even sketchy though they may be, which introduce the student to stability conditions, to money, risk and uncertainty, and to the stochastic approach in econometrics.

On the other hand, though Prof. Fossati has written with recent developments in economic theory in mind, the text remains a version of the scheme originally elaborated more than ten years ago. It cannot be expected, therefore, that the analysis is completely up to date, still less that it should emphasize those particular lines of thought most familiar to Anglo-American economists. Indeed, Keynes gets no more than one incidental mention and Leontief none at all; nor is the 'linear programming' school represented. In fact, following Pareto, the treatment is strictly confined to continuous analysis of the familiar marginal type, easily expressible in terms of the calculus.

The mathematics, it should be noted, are largely relegated to appendixes to the various chapters. The exposition is designed to be simple, clear and lucid, and it succeeds admirably. There are adequate lists of books and articles to assist the student in his further reading.

R. G. D. Allen

LIPID BIOCHEMISTRY

The Lipids

Their Chemistry and Biochemistry. By Prof. Harry J. Deuel, Jr. Vol. 3: Biochemistry—Biosynthesis, Oxidation, Metabolism, and Nutritional Value. Pp. xxxvi+1065. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) 25 dollars.

THE late Prof. H. J. Deuel set himself to write a single treatise on the chemistry and biochemistry of lipids and with the appearance of this third volume his monumental task is complete. Volume 1 describes the chemistry of the lipids (*Nature*, 170, 727; 1952) and Volume 2 deals with some aspects of their biochemistry: digestion, absorption, transport, and storage (*Nature*, 177, 1050; 1956). The present volume covers other aspects of lipid biochemistry, in particular biosynthesis, oxidation, metabolism, and nutritional value.

After a brief introductory chapter, three chapters (266 pp.) are given to an account of the biosynthesis, oxidation, and metabolism of fatty acids, glycerol, and the triglycerides. Then come chapters on the oxidation and metabolism of phospholipids and their hydrolysis products (18 pp.), on the role of formic, acetic, and propionic acids in fat metabolism (38 pp.), and on the metabolism of branched-chain acids, hydroxy- and keto-acids, di- and tri-basic acids, acid amides, aldehydes, and hydrocarbons (70 pp.). There follows an account of the metabolism of cholesterol and related sterols (60 pp.), the carotenoids and vitamins A (200 pp.), vitamins D (62 pp.), vitamins E (68 pp.) and vitamins K (32 pp.), and the final chapters are devoted to the essential fatty acids (52 pp.) and the nutritional value of fats (99 pp.). The book has three indexes covering 130 pp. Each topic is covered in the same comprehensive and impartial manner which the author has displayed in earlier volumes. More than five thousand references are listed including several to publications in 1956, and only very few trivial errors have been noted in the text.

Prof. Deuel had prepared the text of this volume before his death in 1956, so that, although his colleagues and friends assisted in the later stages of publication, the book remains his. With its companion volumes it will long be a standard work in this field and a tribute to H. J. Deuel's zeal, industry, and enthusiasm. The text is prefaced by a biographical note about the author written by George R. Cowgill.

F. D. Gunstone

ENGINEERING THERMODYNAMICS

Engineering Thermodynamics

Work and Heat Transfer. By G. F. C. Rogers and Y. R. Mayhew. Pp. x+619. (London: Longmans, Green and Co., Ltd., 1957.) 50*s*. net.

THE authors have succeeded in providing the first English publication (rather than English republication of works by American authors) to give a rigorous treatment of fundamental and applied thermodynamics for the engineering student.

The first section discusses the principles of thermodynamics, and here the authors wisely follow the lines of Keenan's "Thermodynamics". They have amplified and added to Keenan's presentation. (For example, they discuss the statement of the second law for a control surface.) In general a simple lucid survey of basic thermodynamics is given, although in the discussion of the thermodynamic scale of temperature rigour has been sacrificed in the attempt to simplify the presentation.

A second section discusses "Application to Particular Fluids". Properties of fluids, non-flow and flow processes, power and refrigeration cycles, properties of mixtures and combustion processes are logically dealt with in a readable yet rigorous fashion. The section on feed heating is not as good as other parts of the book, the distinction between direct contact and surface heating not being adequately developed.

Components used in thermodynamic cycles are discussed in two sections on work and heat transfer. In their discussion of turbo-machinery, the authors point out the limitations of the so-called 'diagram efficiency' or utilization factor (in that the exhaust kinetic energy is used in most turbine stages). It is unfortunate that they do not develop definitions of turbine and compressor efficiency in terms of stagnation states, which are but briefly discussed in the section on isentropic flow.

It is pleasing to note that the heat transfer section is competently and thoroughly written.

If the division of the material into the four sections is somewhat artificial, if the book is a little too wordy and is slightly uneven (the omission of the subject of availability and the inclusion of detailed discussion of turbulent shear flows are examples of this), these are but very small criticisms in comparison with the fine overall achievement this book represents. The authors are to be congratulated on writing an excellent book, for student and teacher, and the publishers are to be congratulated on producing it at a reasonable price.

J. H. Horlock

Microdiffusion Analysis and Volumetric Error

by Prof. Edward J. Conway. Fourth revised edition. Pp. xviii+465. (London: Crosby Lockwood and Son, Ltd., 1957.) 42*s*. net.

ONE may speculate as to the extent to which microdiffusion analysis is practised, but there can be little doubt of the existence of a widespread interest in the subject. This fourth revised edition of Prof. Conway's book contains accounts of many new applications of microdiffusion analysis as well as enlarged and revised sections on the apparatus used and the principles involved. New methods described include determinations of blood ammonia, total nitrogen, using a mercury catalyst, glutamine, enzymes, including acetylcholinesterase, formaldehydogenic steroids, a group of volatile poisons, and organically bound halogens. A description is also given of the method of Burbridge, Hine and Schick (1950) for the determination of acetaldehyde in blood. It may be mentioned that recent work by Lundquist published since the appearance of the work under review throws doubt on the specificity of this method. Acetoacetate in the blood may, under the conditions of the analysis, give rise to amounts of acetone which interfere in the measurement.

Part 3 of the book, a section of about 100 pages, deals with volumetric error. An analysis of the errors of micro methods compared with macro volumetric methods reveals many of the reasons which make micro work a practical possibility.

The book is clearly written and well printed. It should be read not only by those who have an immediate interest in microdiffusion but also by all who use volumetric methods of any kind. Most of the text shows an intimate practical knowledge of the processes described and no analyst could fail to profit from a study of it. The author is not always orthodox in his opinions, but where controversial issues are raised, all the evidence and the opinions of others are clearly and fairly given. The book is well illustrated and has a good bibliography and index.

E. I. JOHNSON

Introduction to the Mechanics of Stellar Systems

By Rudolf Kurth. Pp. ix+174. (London and New York: Pergamon Press, 1957.) 55*s*. net.

THIS book is intended to serve as an introduction to the subject for advanced students. After a discussion of the observational data, chapters are devoted to the mechanics of systems of mass-points, stellar systems as assemblies of gravitating mass-points, stellar systems as gravitating continua, and statistical mechanics of stellar systems. The book as a whole is written from a refreshingly novel point of view, and there is relatively little overlap with other text-books on the subject. Especially noteworthy are the treatments of the recurrence theorem of Poincaré, the little-known theorems of Hopf, similarity transformations and Poisson's equation. Although a study of the book would be of considerable educational value to an advanced student, it would nevertheless give a very one-sided view of the subject without a supplementary study of its more practical aspects. The possibility that the observations of stellar motions in our own Galaxy should be interpreted not as properties of an almost stationary stellar system but as well-preserved evidence of initial conditions during the formation of the Galaxy suggests that much of the book may remain of academic interest only. The reviewer feels that the kinematical rather than the dynamical approach to the study of stellar systems may well prove to be more fertile for further development. Nevertheless, it is important to appreciate the achievements of the dynamical approach as well as its limitations, and this book serves as a useful aid to this end.

R. H. GARSTANG

Cytochemical Methods with Quantitative Aims

Biophysical and Biochemical Approaches. Proceedings of the Symposium held September 27–29, 1956, by the Institute for Medical Cell Research and Genetics, Karolinska Institutet, Stockholm, Sweden. Edited by Dr. B. Lindström and Dr. R. Brown. (Experimental Cell Research, Supplement 4.) Pp. viii+296. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 9.50 dollars.

THIS is a report of a conference held at the Karolinska Institute, Stockholm, in September 1956, which was sponsored by the Institute of Medical Cell Research and Genetics. It consists of twenty-seven papers on different aspects of quantitative cytochemical techniques, the majority of which are physical methods, based on optical, absorption and interference microscopy, and on X-ray techniques, which are taken to include quantitative autoradiography using radioactive tracers. These papers are a mine of information which will be invaluable to all workers in these fields. The chemical techniques are less exhaustively dealt with, but nevertheless some very useful discussions of the micro-determination of nucleic acids by a number of the workers in this field are included. These form a valuable addition to the information given in existing text-books. The supplement is quite reasonably priced and would form a useful addition to libraries which do not subscribe to the whole of *Experimental Cell Research*.

Introduction to Enzymology

By Alan H. Mehler. Pp. viii+425. (New York: Academic Press, Inc., 1957.) 10.80 dollars.

IN this book the author has provided an outline of the main metabolic pathways by a description of the individual enzymes and cofactors concerned. He has not attempted to provide a comprehensive review of each enzyme, with the result that rather arbitrary and sometimes inaccurate descriptions are given (for example, the section dealing with the general properties of flavins and flavoproteins ascribes a spurious ionization constant at *p*H 1·7 to flavins, and contains generalizations concerning the fluorescence, redox potentials and absorption spectra not justified by the experimental evidence available). As the book gives many references to recent publications, it is undoubtedly useful as a guide to current metabolic trends. It is difficult, however, to find any real justification for the title of "Introduction to Enzymology". Little or no discussion is devoted to the general properties and theoretical principles of enzymic catalysis; hence very few unifying hypotheses of the type valuable to a student are developed. To those people who have been awaiting publication of a book illustrating in detail the general principles of enzyme chemistry this work will therefore be disappointing. It can be recommended only as a reasonably up-to-date book on metabolism at the level of the individual enzymes. Contrary to its title, it should be of more use to the experienced investigator than to the beginner.

VINCENT MASSEY

THE BRITISH NORTH GREENLAND EXPEDITION, 1952–54

SCIENTIFIC RESULTS

By R. A. HAMILTON, O.B.E.

THE British North Greenland Expedition carried out a programme of research in Dronning Louise Land, north-east Greenland, and on the northern part of the inland ice. The scientific plans were outlined[1] before the departure of the expedition in July 1952; the purpose of this article is to summarize the scientific work which was carried out.

The expedition's bases were at Britannia Sø (77° 09′ N., 23° 36′ W., 229 m.) and at 'Northice' (78° 04′ N., 38° 29′ W., 2,343 m.) on the inland ice. Many journeys were made and one party made a traverse across the inland ice from Britannia Sø to the Thule district on the west coast. A general description[2] of the expedition by the leader, Commander C. J. W. Simpson, was given in a lecture to the Royal Geographical Society before Her Majesty the Queen, the expedition's patron.

Survey

An aerial survey of Dronning Louise Land had been carried out by the Geodetic Institute, Copenhagen, in 1950. Captain Hans Jensen, and after his death in an accident, Brooke[3], extended the triangulation of Germania Land which had been started by the *Danmark* Expedition and completely triangulated the whole of Dronning Louise Land. A map on the scale 1 to 250,000 is being produced by the Institute. A further aerial survey of north-east Dronning Louise Land was carried out by R.A.F. Coastal Command[4], and from this a more detailed map on the scale 1 to 50,000 has been constructed by Arnold[5].

During the traverse of the inland ice the altitude of the surface of the ice sheet was measured at intervals of about 4 km. by trigonometrical levelling[6]. Paterson and Slesser[7] have described the method of survey and estimated the standard error of the altitude of the higher stations to be 10 m.

Geology

The geologists Peacock and Wyllie made a geological reconnaissance of Dronning Louise Land and of southern Germania Land. Archæan gneisses unconformably overlain by what are believed to be representatives of the two Precambrian sedimentary groups of north and east Greenland were discovered in western Dronning Louise Land[8], separated by a structural break from Caledonian schists farther east[9]. Four metamorphic zones culminating in lower amphibolite facies have been tentatively outlined, including a broad zone of low-grade cataclastic metamorphism in the originally high-grade Archæan gneisses. In southern Germania Land, Wyllie discovered altogether higher-grade gneisses[10] which contain basic intercalations of considerable interest, and are intruded by granite in the eastern part of Saelso. It is believed that Dronning Louise Land lies near or on the western boundary of the East Greenland Caledonian orogenic belt, and that much deeper Caledonian structures are exposed in southern Germania Land.

Meteorology

Meteorological observations were made by Hamilton and Rollitt at Britannia Sø and at 'Northice'. The 'Northice' observations have been published in full[11] and climatological summaries[12] have been made of the observations of both stations. The temperature gradient in the air one or two metres above the surface of the inland ice was determined both at 'Northice'[13] and on the traverse across the inland ice[14] by measurement of the optical index of refraction. By this method the errors caused by the diffusely reflected solar radiation on thermometers[15] are avoided.

A detailed study[16] of the synoptic meteorology of north Greenland in the midsummer period shows that the tendency for the glacial anticyclone to be established is disturbed by waves and depressions and their associated fronts which can be followed on the 700-mb. charts. A similar study of midwinter conditions is being made.

Measurements of humidity were made at Britannia Sø[17] by a lithium chloride hygrometer: the observations suggest that at low temperatures in calm weather in the dark winter, hoar frost is not deposited until the air is saturated with respect to water.

Visual observations of aurora were made at both stations, at the same time as the meteorological observations. The forms and brightness of the aurora were recorded, using the international classification; the positions were also noted. The information was handed over to Mr. J. Paton, of the Department of Natural Philosophy, University of Edinburgh, and has been plotted on charts for each night covering the region bounded by geomagnetic latitudes 53° and 84° and geomagnetic longitudes 70° and 90° (English Channel to north Greenland). Brief analysis of these data indicates that the auroral frequency was greater than had been expected[18]. The data will be examined more fully when the collection of the information made during the solar cycle 1951–62 is complete.

Gravity

The value of gravity was determined at approximately three hundred points on the traverse of inland ice[19] with a standard error of less than 5 milligals. The results show that the Earth's crust, with its superimposed ice load, is approximately in a state of isostatic equilibrium. In the eastern part of the ice sheet, where direct determinations by seismic methods were not possible, ice thicknesses have been estimated from the values of gravity.

During the winter when the lake was frozen, Bull[20] developed a technique of measuring the depth of the

lake by gravimetric methods and was able to construct a contour map of the lake bottom.

Glaciology

The expedition planned to measure the thickness of the ice sheet by seismic methods, but neither Cadd in the first year nor Bruce in the second year was able to detect reflexions from the ice – bedrock interface at any point between Dronning Louise Land and 'Northice', and it was not until shortly before the expedition was due to come back that an energy return was detected at a point farther west. Thereafter, strong reflexions were obtained west of a separating line[21] running approximately 330° through 77° N., 45° W., but no reflexions could be obtained east of it. In this region the bedrock is approximately 200 m. below sea-level. The seismograms indicate that the reflexion coefficient east of the separating line is less than one-hundredth of that at points west of it. Bull suggests that the phenomenon may be explained by assuming that the bottom of the ice is melting to the east of the separating line and that the thickness of ground moraine varies greatly across it. The altitudes of the seismic stations on the inland ice were computed[22] from the aneroid readings, by the use of meteorological upper-air charts, with an estimated error of 13 m.

In addition to measuring the altitudes of the stations on the gravity traverse, Paterson[6] also determined the surface slope of the ice sheet at a number of places. These enabled Bull[23] to calculate the shear stress on the bed from Nye's formula. The values of shear stress in the east are lower than those in the west, and it is suggested that the difference may be due to bottom melting in the east.

At about thirty points on the gravity traverse the firn structure was examined. A Rammsonde was used for measuring the resistance to penetration which had been related to the density by a series of calibrating experiments[24] at 'Northice'. The soundings show that the mean annual accumulation for the period 1948–53 was about 13 gm./cm.^{2} and was almost constant along the gravity-traverse route, except near the coasts, where the accumulation is less, due, presumably, to increased abflation. Except near the coasts, the annual accumulation in the eastern part of the traverse for the period July 1953–July 1954 was approximately[25] 16 gm./cm.^{2}.

Beacons were erected on the inland ice and their positions, as well as the height of a mark above the snow surface, were accurately determined, so that if these are remeasured about twenty years later the mean movement of the ice sheet and the net accumulation during the period can be determined[26].

A pit dug to a depth of 14 m. at 'Northice' enabled the annual accumulation back to the year 1878 to be determined[27]. This decreased during the last part of the past century and continued to decrease to a minimum value in 1940, but has increased again in the past decade.

The regime of two glaciers in northern Dronning Louise Land was studied[27]. There was a net loss from their surfaces of less than 1 m. depth of water equivalent, most of which was compensated by flow from the inland ice. Measurements of the rate of flow indicate that it is 12–20 m. per year.

Lister and Taylor[28] studied the heat balance at the glacier surface. Of the total amount of heat which entered the glacier from above, the contributions due to radiation, condensation and eddy conductivity were 69, 2 and 29 per cent. The proportions of this total heat used in melting, evaporation and conduction into the ice were 54, 34 and 12 per cent. Similar micro-meteorological investigations were made by Lister at 'Northice', but the results have not yet been worked up.

As a result of his study of all the major glaciers of Dronning Louise Land, Wyllie[29] concludes that the decrease in the height of the inland ice and the consequent emergence of rock thresholds is the dominant factor in the final stages of glacial recession. Ice recession in the neighbourhood of Britannia Sø was studied in detail[30].

Physiology

Though the emphasis was on research in the geophysical sciences, a programme of physiological research had been drawn up by the Medical Research Council. A general account of the physiological and medical aspects of the expedition has been given by Lewis and Masterton[31]. Acclimatization to cold was the main line of research. Body-weights were measured weekly and have been compared[32] with comparable weights of intakes into the Regular Army. The annual increase of weight of the expedition members was greater than that of the soldiers and showed also a seasonal fluctuation with a maximum in the early spring. Measurements of fat thickness showed a close correlation with changes of body-weight[32]: the experiments indicated the need for simplification of the technique of measuring subcutaneous fat. The number of sites of the body was reduced from thirty-six to five[33], and subsequent work suggests that the subcutaneous fat at one site (namely, under the scapula) correlates extremely well with changes in body-weight[34].

The effect of seasonal light and darkness on the men's sleep was studied. It was found that although sleep was taken very irregularly, there was no seasonal variation in the number of hours slept in a month. The average sleep taken was just under 8 hr. per day, which may represent the natural biological demand[35].

The men's basal metabolic rate was measured fortnightly: the mean was almost identical with that given for men in Britain. The figures confirm that British means are substantially smaller than the American figures.

The physiological findings reflect the pattern of activity of the men rather than an effect of season *per se*; in any event, the body was shielded from the extremes of environment by clothes and shelter[36].

Measurements of the men's physical efficiency were made; but the results tend to be equivocal. Diurnal temperature measurements remained within normal limits and the blood cells were found to remain constant; there was no rise in the red cell count in men who were subjected to the 2,500 m. altitude of the inland ice. These findings indicate the great stability of many body systems in spite of great fluctuations in the external environment.

Research was also carried out in the nutritional field. By way of experiment, samples of biltong were taken for eating on journeys: its use stimulated a fuller investigation into its calorific value[37].

The observation that husky dogs eat human fæces prompted an investigation which revealed that the

fæces did not contain excess fat[38]. This in turn suggested a full investigation of the calorie requirements of men sledging[39]. There were wide variations, from 4,000 to 5,500, with a mean of 4,800 calories a day. An estimate of energy expenditure tallies very closely with this figure, confirming that the food intake was just adequate.

This research has a two-fold significance. First, it has formed the nucleus of subsequent polar physiological programmes of Antarctic expeditions now in the field. The second feature is the fact that our figures show the sledging ration of 4,200 calories to be insufficient to maintain nutritional balance in the face of extremely hard work in the cold. The Medical Research Council reviewed the whole problem and advances in food technology packaging have been incorporated in prototypes now being tested in the polar regions[40].

On the biological side, the incidence of trichinosis in those dogs which were shot or died in the second year were studied. It was found that the infested dogs were among those which had been brought from west Greenland, where they have been accustomed to eating raw meat, while none of the puppies which had been born on the expedition were infested[41].

The insects which were collected in the Britannia Sø area and placed in the British Museum are all well-known members of the Arctic fauna of Greenland[42]. A botanical collection has been examined by Dr. A. Melderis at the European Herbarium of the British Museum, where the specimens are now lodged.

Small fish, an unusual variety of the Arctic char, *Salvelinus alpinus*, were taken from Britannia Sø and handed over to Mr. G. F. Friend, of the Department of Zoology, University of Edinburgh. These fish are undoubtedly descendants of migratory sea-char which once made their way up a river, into the lake, and established themselves there. Since then, they have been isolated for thousands of years perhaps, and have evolved their own peculiarities, some probably in response to their difficult life in high latitudes and sealed as they are for five-sixths of the year under thick ice. Their eyes, nostrils and lateral-line pores—all sense organs—are large for the size of such small fish. They have a starved and juvenile appearance, while their growth-rate is slower than that of any known race of char. A low, flattened cranial-roof and a 'turtle nose' are other striking features. These add much new material to the picture of the chars as a whole.

Except where stated above, the results of the research carried out in the field have now been worked up and the following list of publications may be regarded as the scientific results of the expedition.

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COLONIAL RESEARCH, 1956-57

FOLLOWING the pattern of the previous report, under the title "Colonial Research, 1956–57"*, are collected the annual report of the Colonial Research Council, the twelfth annual reports of the Committee for Colonial Agricultural, Animal Health and Forestry Research and the Colonial Medical Research Committee, the tenth annual reports of the Colonial Economic Research Committee and the Colonial Pesticides Research Committee, the fourth annual report of the Colonial Products Council, the thirteenth annual report of the Colonial Social Science Research Council, the second annual report of the Colonial Road Research Committee, the annual reports of the Colonial Fisheries Advisory Committee on Fisheries Research, 1956–57, of the Tsetse Fly and Trypanosomiasis Committee, and of the director, Anti-Locust Research Centre. There is also a section on research matters not covered by the reports of the specialist advisory bodies, which deals with building and housing research, the Falkland Islands Dependencies

* Colonial Office. Colonial Research, 1956–1957: Reports of the Colonial Research Council; Committee for Colonial Agricultural, Animal Health and Forestry Research; Colonial Economic Research Committee; Colonial Fisheries Advisory Committee; Colonial Medical Research Committee; Colonial Pesticides Research Committee; Colonial Products Council; Colonial Road Research Committee; Colonial Social Science Research Council; Tsetse Fly and Trypanosomiasis Committee; Director, Anti-Locust Research Centre; and Research Matters not covered by the above Reports of the Specialist Advisory Bodies. Pp. 322. (Cmnd. 321.) (London: H.M. Stationery Office, 1957.) 11s. net.

Survey (an outstanding feature of the work of which has been the air survey of 35,000 square miles conducted during the past two years by Huntings Aerosurveys), meteorology, industrial and engineering research, water-pollution research and geodetic, topographical and geological surveys. For the first time in many years, recruitment of surveyors and cartographical draughtsmen exceeded losses and the total staff on March 31, 1957, was 390, while the number of geologists, geophysicists and geochemists overseas, where geological surveys continued in twenty territories, rose to 211, although some vacancies remained unfilled.

Other than the fact that the work is concerned with problems arising in various overseas territories there is little in common between the several reports, nor is any general conspectus attempted even in that of the Colonial Research Council itself, other than the brief reference to Colonial Development and Welfare Schemes (a list of which is appended to the report). Expenditure on these schemes for the year ended March 31, 1957, was £1,538,412, compared with £1,374,323 in the previous year. A review of the whole field of Colonial research where Colonial Development and Welfare assistance is involved is being undertaken, and the Council will then consider the possible re-allocation of funds between the various fields to ensure that full use is made of remaining funds under the current Colonial Development and Welfare Act to fulfil the various programmes envisaged. Even this, however, gives no true measure of the effort in Colonial research which Britain is making. As the various reports demonstrate, this effort is interwoven with that made by the various overseas Governments themselves, and with that of British as well as Colonial universities, so that a complete assessment is difficult or impossible. Apart from the financial aspect, it represents an appreciable tax on British scientific and technical man-power which the universities and research institutions must be prepared to meet. During the year, thirty-four new appointments brought the complement of the Research Branch of the Overseas Civil Service in March 1957 to 189. In addition, two Research Fellows continued investigations on behalf of the Colonial territories, and fourteen research studentships were awarded.

The Committee for Colonial Agricultural, Animal Health and Forestry Research, which recommended grants totalling £925,921 during the year, still finds difficulty in securing suitable officers for senior posts, although recruitment of scientific staff for overseas duties was a little easier. To ensure closer co-ordination of work on control of pests and diseases, a special sub-committee, the Crop Protection Sub-Committee, was set up jointly with the Colonial Pesticides Research Committee. Under the Technical Aid Agreement, the Food and Agriculture Organization gave expert assistance for surveys of the Rufiji Basin in Tanganyika and the Accra Plain in Ghana, assisted Cyprus in controlling an outbreak of sheep-pox, and provided an expert for a survey of swamp soils in Sarawak. Acknowledgment is again made of the help received from research organizations and universities in the United Kingdom.

Much of the work of the Commonwealth Institute of Entomology is concerned with Colonial problems and 42 per cent of the Institute's identifications during the year were concerned with Colonial inquiries, notable help being given to a survey of forest pests in East Africa and to the investigation of premature nutfall of coconuts in the British Solomon Islands Protectorate. Very satisfactory progress has been achieved in Jamaica with soil surveys, the results of which are being utilized in land rehabilitation schemes in overcrowded areas, while studies on soil fertility are receiving very close attention in nearly all Colonial territories. There is good prospect of remedying the deficiency of major and minor plant nutrients which prevent good growth of crops over large areas of Africa south of the Sahara. The Herbarium of the Commonwealth Mycological Institute is collaborating with the West African Maize Research Unit in a statistical analysis of spore sizes in collections from different parts of the world, and a serious outbreak of leaf-curl disease in flue-cured tobacco in Nigeria led to a recommendation for an immediate preliminary survey of economic-crop diseases. An electronic computer was used in a theoretical investigation for the Tsetse Fly and Trypanosomiasis Committee into the effect of introducing sterilized males into a natural tsetse fly population.

It appears that research results are increasingly being applied in tropical agriculture. Extension of soil conservation measures with the concomitant practice of moisture conservation in areas of low or erratic rainfall has greatly improved farm conditions in Kenya, Swaziland, Uganda, Granada and Somaliland. The soil nutrient status has also become clearer with discoveries of deficiencies of major and trace elements in many parts of Africa, particularly of phosphorus, nitrogen, sulphur, boron and molybdenum. Maize breeding in Africa, particularly with strains from Mexico, has produced a series of high-yielding varieties highly resistant to tropical maize rust, while cocoa hybridization in the West Indies and West Africa has given new material of exceptional yield and early bearing. Organic weed-killers also figure prominently in research programmes: thus, in West Africa a programme to spray 700,000 acres against capsid has been approved, of which about 100,000 acres have been treated with power-sprayers, and about 20,000 hand-sprayers have already been sold to cocoa farmers. Considerable advances have been made in the control of pests and diseases of cotton, and practical and economic measures developed for controlling major insect pests of sorghum and other cereals. Much attention is being given to the prevention of damage by storage pests and valuable advances are being made in control or prevention, particularly with rice, cocoa and groundnuts.

The large regional research organizations have advanced fundamental knowledge of the role and importance of organic matter in tropical soils, the nitrogen and sulphur cycles and phosphate fixation. Advances in banana breeding are recorded in the West Indies and the examination and description of flora continued in East Africa, the Zambezi Basin, Cyprus, Malaya, Tropical West Africa, Jamaica and Trinidad. Particular attention was given to the co-ordination of research and the prompt exchange of information between workers in allied fields. In forestry the cultivation in plantations of the valuable African timber tree, mvule (*Chlorophora excelsa*), was specially examined in collaboration with the Imperial Forestry Institute. Work on hormonal arboricides has established their use in eliminating weed trees when making improvement fellings, and notable success has attended species trials on tropical pines

in Central Africa and the Caribbean, and work on ambrosia beetles in West Africa has led to the adoption of practical measures of control. While attention to animal breeding led to no spectacular results, stock of better quality is continually becoming available and progress in vaccine production and other biological products has permitted a high degree of control of rinderpest and pleuropneumonia of cattle and Newcastle disease of poultry, and much progress was made in fundamental work on protozoal diseases of animals in East Africa. The detailed accounts of the work of the regional organizations include lists of publications. The Committee's report now occupies some 111 pages out of a total of 322.

The tenth annual report of the Colonial Economic Research Committee records the completion of Prof. A. T. Peacock's inquiry on the national income of Tanganyika, and of Mr. D. T. Edwards's analysis, in association with the Jamaican Department of Agriculture, of the economics of small farms in Jamaica. A large-scale study of the economics of farming systems in Africa was commenced and also an investigation of the agricultural economy of Malta. Among new projects priority was given to a study of the economics of road development in Uganda; an economic survey of the Seychelles; a survey of farm production in British Honduras; studies of the Fijian community as an economic unit; and of the effects of diamond mining in Sierra Leone on a predominantly subsistence economy.

The annual report on Fisheries Research, 1956–57, which comprises the reports of the individual Colonial fisheries research stations, records the failure of a special mission to impress on local opinion in Ghana and Nigeria the continuing need for fishery research in West African waters and the consequent winding-up of the West African Fishery Research Institute, Sierra Leone, as an inter-territorial body, though plans have been laid to safeguard the results already obtained by establishing, in consultation with the Sierra Leone Government, a small territorial unit based on the Institute's premises. Both the Federation of Malaya and the Singapore Government have withdrawn from the work of the Regional Fisheries Research Station at Singapore, and this station is also to be wound up. Efforts are being made to place the scientific staff of both stations in other parts of the Oversea Research Service.

Results obtained at the Jinja laboratory of the East Africa Inland Fisheries Research Organization have been used in advising the East African Governments on the probable consequences of proposed changes in legislation for the protection of fish stocks in Lake Victoria. Experimental evidence has now shown that organic sulphur deposited on the lake bed as plant debris has little chance of being converted into available sulphates. Interest in snails as intermediate hosts has led to the observation that the ability of snails living in small streams and pools to survive the dry period depends on their degree of infestation by parasitic nematodes. The effects of DDT on insectivorous fishes have been studied, and work on the food and feeding habits of insect-eating and fish-eating species of fish in Lake Victoria is nearly complete. Steady progress is reported by the East African Marine Fisheries Research Organization, which has correlated the seasonal appearance of the dolphin-fish, *Coryphaena hippuris*, with plankton and hydrographic data.

The Northern Rhodesian–Nyasaland Joint Fisheries Research Organization gave priority to basic research on fish ecology in Lake Bangweulu, the Bangweulu swamps (where the importance of *Vossia* grass is being studied) and the Zambesi and Ianyeti rivers in the area to be covered by the Kariba Dam. From the Fisheries Research Unit, University of Hong Kong, a hydrographic survey of the sea around Hong Kong has now continued for two years and the possibility of developing an edible-oyster industry in Tolo Harbour has been investigated. The West African Fisheries Research Institute had fifteen scientific papers published or in preparation, including a complete scientific survey of the Sierra Leone estuary and an extensive survey of the bottom fauna on the continental shelf off Freetown, correlating this fauna with the nature of the sea-bed and with the food of fish.

The twelfth annual report of the Colonial Medical Research Committee refers to the termination of research on the physiology of hot climates which, in Nigeria and adjacent territories over the past eight years, has been very productive. With this exception, the various fields of research have remained unchanged, although research on trachoma in Jordan had to be suspended. The Research Unit on Tuberculosis in Ghana is now well established and has maintained effective contact with workers in Nigeria and Sierra Leone, while the formation of the Leprosy Sub-Committee has greatly stimulated interest and co-ordination; pilot control measures based on data secured in filariasis research, whether loiasis or bancroftiasis, are increasingly applied or planned. On the recommendation of the Committee, modest block grants have been placed at the disposal of each of the three regional organizations for medical research, in East and West Africa, and the British Caribbean, from which each could make small immediate grants annually to provide some additional research facility required by an individual research worker.

Research on loiasis and onchocerciasis in the Cameroons and Nigeria indicated that use of DDT and dieldrin granules in high concentrations (say, 5 per cent) to spray the mud of breeding-sites of *Chrysops* and *Tabanus* killed all larvæ, a process which, while very costly, may be economical in the rain-forest where the breeding-sites, though scattered and inaccessible, are small in total area. Investigations into the effects of 'Antrypol' and dimercaptosuccinate on the concentration of microfilariæ in onchocerciasis gave promising results. Encouraging results were also obtained in East Africa in the control of filariasis in rural areas by treatment with 5 mgm./kgm. 'Hetrazan' once a week for six weeks and by spraying houses with dieldrin at 100 mgm./ft.^{2} every six months. A pilot control scheme of bilharzia among schoolchildren is to be undertaken in the Mwanza area. Investigations on guinea-worm at University College, Ibadan, point to the value of 'Hetrazan' as a prophylactic for travellers journeying through endemic areas of dracontiasis, while in Tanganyika granulated dieldrin has proved a highly effective larvicide.

No definite evidence of a relation between the frequency of the sickle-cell trait and the parasite-rate or parasite-density was obtained in investigations in Nigeria and Southern Cameroons on malaria and the

sickle-cell trait. At the West African Council for Medical Research Laboratories, Lagos, studies in hepatic pathology showed that monkeys hyper-immunized against Zika virus were more tolerant to the yellow fever virus than the normal controls, while at the Trinidad Regional Virus Laboratory, Port of Spain, research has centred around epidemiological investigations of Ilheus virus infections. Investigations on the yellow fever hazard at the Institute for Medical Research, Kuala Lumpur, have been mainly concerned with whether local mosquitoes and animals can transmit and maintain the disease, whether the presence of other viruses in Malaya would affect its establishment, and methods of vaccination and mosquito-control. The United States Army Medical Research Unit (Malaya), in collaboration with the Institute, the nearby British Military Hospital and the Walter Reed Army Institute of Research, Washington, has made clinical and laboratory studies of children with pyrexias of unknown origin in the General Hospital, Kuala Lumpur, of encephalitis in Singapore and the Federation, and of the ecology of potential vectors of viral diseases in Malaya.

Much progress has been made in building up facilities for nutrition research at the East African Medical Survey and Research Institute, Mwanza, and at Kampala the Infantile Malnutrition Research Unit continued to explore the use of various diets in treating kwashiorkor. The Tropical Metabolism Research Unit, Jamaica, continued work on the composition of tissues in malnutrition, especially of muscle, and some progress was made in the measurement of Krebs cycle oxidations. In a controlled pilot trial in Nigeria, which has now lasted twenty-five months, diphenylthiourea has proved an effective treatment for all types of leprosy in a dosage of 1·0–3·0 gm. daily. It is at least as active as diaminodiphenylsulphone. With an isoniazid it combines effectively, is remarkably free from toxic action, and no evidence of drug resistance has appeared. Diaminodiphenyl sulphoxide also continues to show considerable promise. In studies at Makerere College on the enzymes of *Mycobacteria*, particularly the use of tetrazolium salts to detect dehydrogenases, satisfactory micro-methods have been developed which give consistent results with cultural organisms. At the National Institute of Medical Research studies have been made on the evolution of infection with *Mycobacterium lepramurium* in experimental animals, while at the Medical Research Council Laboratories in The Gambia, observations on the long-term therapeutic effects of 'Hetrazan' in *Wuchereria bancrofti* infections indicate that the maximal effect of non-toxic dosage-levels is not discernible until two years after treatment. In research on the biology of sand-flies in East Africa, work with *Phlebotomus guggisbergi* may provide clues as to the real vector of kala-azar.

The tenth annual report of the Colonial Pesticides Research Committee refers to further studies of the Colonial Insecticides Research Unit, Porton, on the sorption of insecticides by soils, which have shown that repeated sprayings do not affect the sorption-rate, whereas increase of temperature increases the sorption of DDT and dieldrin, and that loss of insecticide by chemical decomposition is not a significant factor. A preliminary investigation has been made of the properties of residual DDT and dieldrin on some surfaces used in house construction, and the relative toxicities of the organic phosphorus insecticides, diazinon, chlorthion and malathion, to houseflies and some species of mosquitoes have been determined. Promising new variations in olfactometric technique have been developed at the Imperial College Field Station, Silwood Park, while at Long Ashton Research Station a technique has been evolved for controlling leaf-spot disease of Lacertan bananas. At Urambo, Tanganyika, the Colonial Pesticides Research Unit successfully controlled heavy infestations of bollworm (*Heliothis armigera*) and stainers (*Calidea*) on cotton by weekly sprayings of DDT at 1 lb./acre, with BHC for aphid control when required. Control of bean fly, *Agromyza* (*Melanagromyza*) *phaseoli*, has been obtained with seed dressings of emulsifiable concentrates of aldrin, endrin and dieldrin. The Biting Fly Research Unit, Uganda, extended its facilities for entomological research and has established a laboratory colony of *Stomoxys calcitrans*. In filariasis research in Fiji residual sprays of DDT and dieldrin gave satisfactory control of mosquitoes resting in houses, and in transmission experiments high infection-rates were obtained with *A. polynesiensis* Marks in feeding experiments. In the Western Sokoto Malaria Control Pilot Project an improved technique for sampling insecticide deposits on mud surfaces was evolved, and on the 100-acre experimental plot at Kidichi Mdo, Zanzibar, effective economical control of *Pseudotheraptus wayi* on coconuts was obtained using 10 per cent DDT with 1 per cent coumarone indene resin dissolved in a mixed aromatic petroleum solvent.

Stress is also laid on research being done in the Colonies without the assistance of the Committee: for example, the preliminary survey at Aden of the relative importance of various pests of cotton; the promising results obtained in control of various weeds in Bermuda; the control of olive leaf spot (*Cycloconium oleaginum*) in Cyprus with 10 : 1 : 100 Bordeaux mixture; of scale insects on *Hibiscus* sp. in Malaya with dieldrin and 'Nicotox'; and of white copper borer, *Anthores leuconotus* Pasc., with 0·5 per cent dieldrin in Tanganyika.

Almost half the fourth annual report of the Colonial Products Council and Laboratory is concerned with work conducted outside the Laboratory but under the direction or with the assistance of the Council. The 745 inquiries handled by the Laboratory during the year, of which sixty-two were still in hand, included such varied subjects as cedarwood oil, coconut products, the development of *Crambe abyssinica* as an oilseed crop, the relative nutritional value of *Oryza glaberrima* and *O. sativa*, the packing and transport of fresh mangoes, nutritional biscuits from local ingredients for school-children in Uganda, and the extraction of vitamin C from the West Indian cherry. Among the ninety-five investigations completed by the Laboratory during the period were those relating to oil of *Leptospermum citratum*, oil from the bark of *C. pedatinervium* as a source of safrole, Illipe butter, sugar cane wax, sisal wax, starches from arrowroot and sago, and animal feeding stuffs from waste materials. Other work included the separation, by chromatographic and counter-current techniques, of the constituents of pyrethrum, work on the seaweed *Corallopsis opuntia*, which has good jelly-ing properties, the comparative properties of abaca fibre from Borneo, Sumatra and the Philippines, and pulping trials of *Ricinodendron rautanenii* timber from Northern Rhodesia and of British Honduras slash pine, *P. caribaea*.

Further work on the curing of the cacao bean and on the structure of the cacao leucocyanidin compounds was carried out at the Colonial Microbiological Research Institute, Trinidad, where a 3 : 4-diol structure has been indicated for peltogynol in place of the accepted structure, and the isolation of the intermediate oxidation products of substituted catechols is in progress. The Sugar Technological Laboratory, Trinidad, carried out much work on the fundamental physico-chemical aspects of clarification and also further work on the removal of evaporator scale and the chemistry of constituents of ammoniated molasses, but pilot-plant work indicates that the production of lævulinic acid from molasses is unlikely to be economical. At Makerere College, besides investigations on the natural products of East African plants, the methane fermentation of vegetable wastes has been studied up to pilot-plant scale; and studies at the Forest Products Research Laboratory, Princes Risborough, on the production of fibreboard from secondary Colonial timbers indicated that after treatment with steam alone in the 'defibrator', pulp from all the species tested required further refining to give boards of adequate strength. Work on sugar derivatives continued at the University of Birmingham, where the series of oligosaccharides produced by acid reversion of N-acetyl-D-glucosamine has been fractionated and two disaccharides isolated, and a unit has been established for studying the pharmacological activity of extractives from plants and other materials of interest to Colonial territories. The study of medicinal plants which might contain hepatoxic agents by the Medical Research Council's Toxicology Research Unit continued and also work on the constitution of the alkaloid dioscorine at University College, Cardiff, chemical investigations on the leaves of *Anona senegalensis* and the structure of the pectic compounds of *Agave sisalana* flesh at the University of Edinburgh. Further investigation at the Institute of Animal Physiology, Cambridge, of extracts of the seeds of *Dichapetalum toxicarium* indicates that a major part of the active fraction behaves mainly as a C_{18}-fatty acid with one double bond and one fluorine atom.

In its second annual report the Committee on Colonial Road Research notes a slow but steady build-up of the Colonial Section of the Road Research Laboratory, which, at the end of March 1957, was short of its complement by two scientific officers, five experimental officers and five assistants (scientific) and emphasizes the adverse effect of the restrictions and delays in new buildings. Federal Nigeria proposes to establish its own central Road Research Laboratory, and Western Nigeria and Northern Nigeria are building up their Materials Testing Laboratories. Research teams have been recruited to study road-making materials available in Colonial territories and pavement design, and a survey has been made of published information on corrugations, theories advanced to explain their formation, and on methods of alleviating or preventing them by selection and treatment of road-making materials.

The bearing capacity of representative soils from Uganda, Northern Rhodesia and The Gambia over a range of densities and moisture contents has been determined using the California bearing ratio test. Road construction problems with fine-grained cohesionless sands occurring in coastal and desert areas have been investigated in connexion with the proposed Ado–Badagry road in Western Nigeria and the George-town–Rosignol road in British Guiana. A range of full-scale experiments on the use of rubber in surface dressing, bitumen macadam and rolled asphalt is in progress, and examination of the economics of roads and road transport in under-developed territories has begun. This work has included a review of methods of road accidents with the view of helping territories to adopt methods within their capacities and suited to their needs, and ensuring that the data are so presented that they provide a reliable measure of the pattern of road accidents and their economic importance.

To the thirteenth annual report of the Colonial Social Science Research Council are appended the customary reports for 1956–57 of the East African Institute of Social Research, the West African Institute of Social and Economic Research, the Institute of Social and Economic Research, University College of the West Indies and the Rhodes–Livingstone Institute. Work was commenced on the project initiated at University College, Ibadan, for a history of Benim, to be financed jointly by the Carnegie Corporation and the Governments of Nigeria, and a study of family attitudes in Jamaica. The fourth volume, "Bantu Languages of Africa", of the Handbook of African Languages is in the press, and forty volumes of the Ethnographic Survey of Africa have now been published, while further sections on peoples of East Africa and of Nigeria are in preparation. A new relation between the East African Institute of Social Research and the Social Studies Department of Makerere College is being inaugurated which will establish a closer link between teaching and research, while maintaining the Institute as an autonomous organization within the College. The Institute of Social and Economic Research, University College of the West Indies, is studying West Indian agriculture and agricultural development, the labour market, the analysis and supplementation of West Indian national accounts and the role of investment in economic development. At the Rhodes–Livingstone Institute for Social Research, studies are in progress of European communities in the Copperbelt and in Southern Rhodesia; of the economics of peasant farms and of African education; and of urban sociology and the sociology of industry as well as two tribal studies.

The major field of activity of the Tsetse Fly and Trypanosomiasis Committee was in chemotherapy, and at a conference at the Colonial Office agreement was reached on procedures for the fullest co-ordination of full trials of promising new trypanocidal drugs and the prompt dissemination of such results. The new procedures have already been implemented, and the suramin complexes developed at the West African Institute for Trypanosomiasis Research appear to offer a considerable increase in the period of protection obtainable. In human trypanosomiasis the Institute has closely studied changes occurring in the saliva of tsetse infected with the *brucei* group of trypanosomes, and its clinical trials indicate that 'Malarsen' is a valuable alternative for treating *T. gambiense* infection under field conditions, especially in late or relapsed cases. Research on the forest species of tsetse continued at the Field Station and a comparative experiment on 'man–fly contact' was started near Kaduna during the rains. The study, by the East African Trypanosomiasis Research Organization, of the resting-places of the tsetse flies *Glossina swynnertoni*, *pallidipes* and *morsitans* is

likely to lead to new ideas on the use of insecticides. An investigation of the mechanism of water control in the pupa of *Glossina* is contributing to an understanding of the success and failure of some current methods of reclamation.

At the Sukulu Laboratory a small hospital was opened for the reception of patients from the lake-shore fly-belts, and a joint investigation with the Kenya Medical Department has shown that in that area *G. pallidipes* is a carrier of *T. rhodesiense*. The epidemiology of *palpalis*-borne sleeping sickness in Uganda is also being investigated. In Northern Rhodesia trypanosomiasis research has been limited to drug trials and prophylaxis. The Veterinary Department of the Northern Region of Nigeria is pursuing a vigorous programme of research into cattle trypanosomiasis, while the Department of Veterinary Services, Tanganyika, has compared the protection given by prothidium, ethidium–suramin complex and *RD*290 suramin complex with that given by 'Antrycide' prosalt. Prothidium was also the outstanding new prophylactic tested by the Department of Veterinary Services, Kenya.

The report of the director of the Anti-Locust Research Centre for 1956–57—in which the Centre received 984 reports of the desert locust situation from thirty-two territories, including reports on low-density locust populations from survey officers in the Somali Peninsula, Ethiopia and parts of Arabia—notes that the desert locust situation improved somewhat in Eastern Africa, Iran, Pakistan and India, although heavy breeding occurred in the Sudan, the French Chad territory and the Niger Colony. A panel of international experts which met at the Anti-Locust Research Centre in April 1956 recommended that permanent surveys of the whole of the distribution area should be established by all governments concerned, and that all information on the state of desert locust populations and relevant weather phenomena should be centralized.

The International Red Locust Control Service continued studies on red locust populations in relation to vegetation dynamics and on control methods, and the International African Migratory Locust Organization became a permanent international body in 1956, when a research service was established. The Anti-Locust Research Centre continued to work on phase variation and its inheritance; maturation and fecundity in the red locust; weight and water-content of the desert locust in relation to flight and the life-cycle of *Eyprepocnensis plorans*, *Acrida bicolor* and *Gastrinargus africanus*. Annual and seasonal frequency maps of the incidence of desert locust swarms and hoppers were completed and maps of the major seasonal swarm movements were prepared.

OBITUARIES

Dr Willis R. Whitney

With the death on January 9 of Dr. Willis Rodney Whitney, at the age of eighty-nine, there ended a very remarkable career.

Although Dr. Whitney was a first-class scientist in his own right, his great contribution was the organization and successful direction, for thirty-two years, of the Research Laboratory of the General Electric Co., Schenectady, New York. It is hard to understand now what a truly pioneer task this was, for in 1900 there were no organized industrial research laboratories in the United States. He had to prove that industrial research could be made to pay. When he did this, other industries quickly followed General Electric's example. To-day, a research laboratory is considered essential for industrial success.

Born in Jamestown, New York, on August 22, 1868, Dr. Whitney's interest in science began with the acquisition of a microscope when he was in high school. After graduating from the Massachusetts Institute of Technology in 1890, he first spent four years as instructor in chemistry there, then went to the University of Leipzig, where he received his Ph.D. degree in 1896. After six months at the Sorbonne, he returned to the Massachusetts Institute of Technology as assistant professor and later full professor.

It was at this point that E. W. Rice, vice-president of the General Electric Co., visited him and proposed that he should start a research laboratory—a thing new to industry. The fact that it was an experiment appealed to Whitney—he loved an experiment. But he also believed in proceeding cautiously and slowly, feeling one's way. So he agreed to try it on a part-time basis, spending three days a week in Schenectady and the other three at the Massachusetts Institute.

His first laboratory was a barn in the rear of Dr. Steinmetz's house, and the laboratory staff consisted of Whitney and half the time of an assistant shared with Dr. Steinmetz. When the barn burned down in the following year, he moved to a building in the Schenectady works, and gradually began to add more employees, being very careful to preserve the atmosphere of friendly co-operation.

This atmosphere he himself generated by personal example. As long as the size of the laboratory permitted, he made a practice of visiting every member of the staff every day. His usual greeting on these visits was, "Are you having any fun?". To him, research was fun, "the finest of sports", as he once expressed it. Frequently, on his visits, he brought some new project or experiment, suggested by company activities or scientific progress, which he literally peddled from room to room, but seldom assigned.

It was one of his key principles that members of his staff were given freedom, in proportion to their proved ability, to choose their own research problems, and to publish important results promptly in their own names. He was a pioneer in the championing of such publication.

Optimism, enthusiasm and sound judgment were conspicuous qualities of Dr. Whitney, but above all was his devotion to science. It was literally true of him that science was his religion. He often talked about religion, but always concluded that the "search for truth" was the best kind of religion.

Scientific curiosity, which he once defined as the greatest asset of a research man, was his most conspicuous quality. If you visited him on a Saturday afternoon, you were likely to find him in a field near his home, putting a small piece of iron wire in the stem of a golden-rod and surrounding it by a high-frequency coil, to find out whether it was the heat of

the bug inside that caused the swelling called a gall to grow. Or you might find him sitting on a log in the woods, counting the mosquitoes that alighted on him and on a quarter of beef beside him, to find out how they knew what to bite.

Dr. Whitney retired as director in 1932, becoming an honorary vice-president of the General Electric Co. But he still came to the laboratory every day, at first devoting his time to personal experiment, his first love, which he had missed during his directorship; and later to visiting the research workers, with interest and encouragement.

Dr. Whitney's success as a pioneer of industrial research is a lasting contribution. The secret of that success was a combination of remarkable personal qualities—friendliness, mental vigour, breadth of interest and knowledge, stimulating originality, delightful flashes of humour, modesty, courage, directness and simplicity. A. W. Hull

Dr. K. H. Barker

Dr. K. H. Barker, who died suddenly in London on March 3, was born in Manchester in 1925 and educated in the Department of Physics at the University of Manchester, graduating in 1948. His university education was interrupted between 1945 and 1947 when he worked on the Tube Alloys Project in the Department of Physics at the University of Liverpool.

In 1948 Barker started research work in cosmic-ray physics at Manchester, under the direction of Prof. P. M. S. Blackett. At the beginning of his research career he joined my group, then engaged in studying high-energy nuclear collisions using a cloud chamber equipped with an electromagnet. This collaboration lasted until his death, a period of almost ten years without a break. His death is a very great loss to the group and to the subject of high-energy nuclear physics in which he had achieved a world-wide reputation.

The Manchester electromagnet was moved to the Observatory on the Pic-du-Midi in the French Pyrenees in the autumn of 1949. Barker was responsible for installing the magnet and cloud chamber in the mountain laboratory at an altitude of 9,500 ft. Altogether, he spent between two and three years of his life working with the apparatus. In the early years he often climbed to the mountain top during the winter months; but a cable railway has now been installed. Barker was a first-class experimental physicist able to operate and maintain efficiently a complicated piece of equipment in very difficult circumstances.

In 1950 Barker obtained a very valuable set of photographs showing many decays of V^0-particles. From the analysis of these pictures the group demonstrated, for the first time, that the V^0-particles, discovered by Rochester and myself in 1947, consisted of two kinds: neutral Λ-hyperons which are heavier than the proton and heavy mesons, with mass intermediate between the π-meson and the proton. Barker played a leading part in obtaining and interpreting these photographs. He also observed, in 1950, the first decay of a Ξ^--hyperon.

In 1953 Prof. Blackett and a number of his staff moved from Manchester to the Imperial College of Science and Technology, London. Barker was at once appointed a lecturer in physics at the Imperial College and continued to spend part of his time at the Pic-du-Midi working on the same general research programme. During the past year or so the group has been studying the properties of nucleon–nucleon collisions with energies of 50 GeV. and upwards. In this work Barker collaborated very successfully and fruitfully with French physicists from Prof. Leprince-Ringuet's Laboratory at the École Polytechnique in Paris. At the time of his death he was enthusiastically planning new experiments in high-energy nuclear physics using an accelerator, instead of the cosmic-rays, as a source of particles.

Barker was a good teacher, both of undergraduates and research students, and, as a friendly and helpful colleague, will be sadly missed by the staff of the Department of Physics at the Imperial College.

C. C. Butler

NEWS and VIEWS

Mastership of Clare College, Cambridge : Sir Henry Thirkill, C.B.E.

Sir Henry Thirkill retires from the mastership of Clare College, Cambridge, on September 30 next. Apart from the war years 1914–19, Sir Henry has been in residence since he entered the College as an undergraduate in 1905. He sat for the Natural Sciences Tripos, Part I, in 1907, and for Part II in the following year. He was elected a Fellow of Clare in 1910, having embarked on research at the Cavendish Laboratory under J. J. Thomson, being later one of his demonstrators in the somewhat precarious days when the professor was personally responsible for his assistant's stipends. During the First World War, Thirkill served in the Royal Engineers, being O.C. Wireless in East Africa, 1915–18, and receiving the Military Cross. On returning to Cambridge, he was appointed College lecturer and a University lecturer in experimental physics. It is, however, as tutor of Clare College from 1920 that he will best be remembered by many generations of Clare men—not only for his gentle if determined guidance but also for his hospitality at breakfast or Sunday evening music and, for the more energetic, on the tennis or squash court. Though made president of the College in 1930, he retained the tutorship until he was elected master in 1939.

Always a great worker, Thirkill found time from an early date to serve the University as well as his College. He was elected a member of the Council of the Senate so far back as 1927, serving continuously for thirty years. This was only a beginning; for many years he was also a member of the General Board of the Faculties, of the Financial Board and of many other committees. It would be difficult to find a man in any age who has given longer or more devoted service in the sometimes thankless task of university administration. Thirkill was vice-chancellor in the particularly busy years 1945–47 when plans for post-war developments were being prepared on every hand. It fell to him to entertain the many war leaders on whom honorary degrees were conferred. His brilliant speeches at the

luncheons following the degree congregations will long be remembered. It will be difficult for old Clare men to think of the College without Thirkill as master or tutor, but they may be comforted by the knowledge that he will continue in residence on his retirement.

Sir Eric Ashby

THE Fellows of Clare College have announced their intention of electing Sir Eric Ashby into the mastership of the College on the retirement of Sir Henry Thirkill. Sir Eric, who has been vice-chancellor of The Queen's University, Belfast, since 1950, was elected on March 13 into a Fellowship of the College. From the City of London School, Ashby went to the Imperial College of Science and Technology, where he later became a demonstrator in botany and, after two years in America as a Commonwealth Fellow, a lecturer during 1931–35. His next post was reader in the University of Bristol until 1938, when he was appointed professor of botany in the University of Sydney. The sea-trip to Australia with a young family was so turbulent that Ashby swore never to return. Fortunately for the cause of education in Britain, the busy years that followed made him forget his resolve. Scarcely was he settled in Sydney when the Second World War made heavy demands upon him. He was chairman of the Australian National Research Council, 1940–42, and director of the Scientific Liaison Bureau, 1942–43, having conducted an inquiry for the Prime Minister into the enlistment of scientific resources in 1942. In 1945 he went to Moscow as Counsellor and chargé d'affaires at the Australian legation. His experiences there are recounted in the Penguin book, "Scientist in Russia". In 1946 he left Australia to become Harrison professor of botany and director of the Botanical Laboratories in the University of Manchester, where he remained until he went to Belfast as vice-chancellor. While continuing his interest in botany, Ashby has found time for many other activities, including the administration of research, having been a member of the Advisory Council on Scientific Policy (1950–53), of the Advisory Council on Scientific and Industrial Research since 1954 and chairman of the Scientific Grants Committee since 1955. Above all, he is well known as a writer, and thinker, on educational problems.

Research at Imperial Chemical Industries : Mr. R. M. Winter

MR. R. M. WINTER, who is retiring from the post of research controller of Imperial Chemical Industries, Ltd., after thirty years service with the Company, was born in Scotland in 1896, and emigrated in early childhood to New Zealand, where he received most of his formal education. On graduating B.Sc. in 1916, he volunteered for military service and served with the New Zealand Division in France, where he was wounded. At the end of the War he worked for a time at the Royal College of Science as a research student under Prof. H. Brereton Baker, and on his return to New Zealand was awarded an 1851 Exhibition science research scholarship. After a year's research at the Rothamsted Experimental Station, he joined the staff of the Explosives Research Department at Woolwich Arsenal, where he remained until the end of 1927. He joined Synthetic Ammonia and Nitrates, Ltd. (now the Billingham Division of Imperial Chemical Industries), early in 1928 and was transferred to the General Chemical Division as research manager in 1931. In 1937 he moved to Head Office as chief assistant to Dr. R. E. Slade, who was then research general manager, and was appointed research controller in 1946.

Dr. M. A. T. Rogers

DR. M. A. T. ROGERS, head of the Academic Relations Department of Imperial Chemical Industries, has been appointed research controller in succession to Mr. R. M. Winter. Dr. Rogers was born at Mill Hill in 1911, and received both the B.Sc. and Ph.D. degrees from University College, London, where he was a Tuffnell Research Scholar and the Ramsey Memorial Medallist for 1933. Dr. Rogers joined the Dyestuffs Division of Imperial Chemical Industries as a chemist in 1934, and served in the Azo Section until 1936, the Textile Auxiliary Section until 1939 and the Exploratory Research Section until 1942. In that year, Dr. Rogers joined the Royal Artillery, and when he returned from his military service he became engaged in research on penicillin with Sir Robert Robinson at the Dyson Perrins Laboratory, Oxford. In 1946, Dr. Rogers joined the Medicinal Research Division, and in 1949 he became head of the Academic Relations Department of the Dyestuffs Division of Imperial Chemical Industries.

Atomic Energy Insurance

THE second international Atomic Energy Insurance Conference, held in London during February 26–28, under the chairmanship of Mr. H. T. Silversides, issued in a widespread agreement by representatives from fifteen European countries on the broad approach to the insurance of risks arising out of the use of nuclear energy reactor installations. Essential features of pool management agreements were discussed, and it was decided that the material damage risks to be pooled should be the insurance of damage to nuclear installations (defined as nuclear reactors, nuclear power stations, and plant and facilities for producing nuclear energy), including contamination by radioactivity. Third party liability for damage and loss of life or injury arising out of the use of nuclear installations is also to be pooled, and each reactor and third party liability must be comprehensively covered. All the participants in the Conference endorsed the principle that a single insurance policy should be effected by the owner or operator of the reactor, who should also accept all responsibility for radiation liabilities for contractors and suppliers of parts, and undertake to indemnify the contractors and suppliers from any legal liability for radiation risks. The Government of the United Kingdom has already agreed to this approach in fixing an absolute liability at law and requiring insurance to a sum of £5 million or proof of equivalent liquid assets. A special committee of representatives of Belgium, France, Germany, Holland, Italy, Sweden, Switzerland and the United Kingdom is meeting in April to consider hazards, evaluations and surveys ; the basis of premium rating ; and the policy cover to be offered ; while legislative aspects of nuclear insurance will continue to be handled by the Organization for European Economic Co-operation and the European Committee for Insurance.

Industry and Atomic Power

AN illustrated brochure entitled "Atomic Power Achievements" (chairman's address at the Fifty-seventh Annual General Meeting, London, September

5, 1957. Pp. 36. London: General Electric Co., Ltd., 1957) describes the part to be played by the General Electric Company, Ltd., in the implementation of the British nuclear power programme. The Company is building at Hunterson on the Ayrshire coast one of the world's largest full-scale commercial nuclear power stations, for use by the South of Scotland Electricity Board. Photographs of models of the station and details of its capacity are given in the brochure. The generating capacity will be 360,000 kW., of which 320,000 kW. will be fed into the National Grid system, the remainder being consumed in the station. The two reactors will be loaded initially with 500 tons of uranium. The graphite core of each reactor will consist of about 115,000 graphite blocks and will be enclosed by a spherical steel pressure-shell 70 ft. in diameter. In addition to the reactors and the turbine hall, housing six turbo-generator sets with feed water and condensing plant, administration and laboratory blocks and a number of ancillary structures will be built. Between the two reactor structures a pond for the storage of irradiated or spent fuel elements from the reactors, prior to their removal to the processing plant, will be constructed. The first reactor and three turbo-generator sets are scheduled for commissioning in 1961 and the whole station will be fully operational in 1962.

Milford Haven Conservancy Bill

On March 25, during the committee stage in the House of Commons of the Milford Haven Conservancy Bill (see *Nature*, April 5, p. 937), the amendments moved by Lords Silkin and Ogmore and others were negatived, although Lord Brecon, for the Government, promised to consider further before the report stage the desirability of placing the provision for amenities in a separate section. Some disturbing disclosures were made during the debate. Lord Ogmore revealed that the Chairman of the Pembrokeshire County Council had opposed the suggestion that the whole scheme for development should first be explained to the nation in a White Paper, and appeared to be concerned solely with local benefits. The Minister of Housing and Local Government had taken a wider view, and had refused the Esso Company permission to develop 1,000 acres, and permission to develop 350 acres had been given only under very stringent conditions. Lord Ogmore pointed out that there were eight developments proposed in the area; besides this proposal for a £20 million refinery on the north shore, there was the landing stage for the harbour at Popton Point capable of taking the largest tankers afloat; a £9 million project for two dry docks, five wet-berths and a discharging pier; a deep-water unloading berth for iron ore; the iron ore stocking ground at Angle or near by; another refinery on or near the Haven; a group of chemical and kindred factories; and a ship-repairing project at Pembroke Dock.

These developments, which it was estimated would bring a further 50,000 people into the area, were likely to have a profound effect on the whole of west Wales and, apart from the effect on the National Park area itself, Lord Ogmore and other speakers were concerned that any essential development should not be allowed to create industrial slums in the way that some nineteenth-century developments had done. His contention that due regard should be had to cultural and social development was strongly supported by Lord Lloyd and by Lord Hurcomb, who welcomed the writing into the Bill of the powers which the Minister of Power agreed to write into the Electricity Bill. Lord Hurcomb was concerned that planning authorities should not be allowed to give free play at the expense of all other considerations to any profitable industrial or commercial development, and referred to the probable deleterious effect of the proposed dredging on the marine biological station at Dale Fort. As regards oil pollution, he thought that much of the evil could be avoided if the responsible authorities were vigilant and exercised their great powers. The oil companies in Britain had always taken an enlightened attitude.

Lord Brecon, in replying to the debate, said that the Government had very carefully considered the amenity question, and thought that the Bill, as it stood, provided all the care for amenity that will be required in the development of Milford Haven. The Minister of Housing and Local Government and for Welsh Affairs had taken great personal interest in the question, and could call in all the planning applications for consideration by his Department. The National Parks Commission would be represented on the Board, which would have greater responsibilities for amenities than any other harbour board in Britain. The Government, he said, is really keen to see that full consideration is given to amenity, and that as little despoliation as possible occurs in the area; but matters of cultural and social development are the responsibility of the local county council, the committee for further education, youth clubs and other organizations.

Entomologia Experimentalis et Applicata

Within a year of the first appearance of the new *Journal of Insect Physiology*, yet another scientific journal dealing with entomology has made its debut. *Entomologia Experimentalis et Applicata* (**1**, No. 1; February 1958. Pp. 72. Published quarterly. Annual subscription (for a volume of at least 320 pages): 32 Dutch guilders; 63*s*.; 8.50 dollars. Amsterdam: North-Holland Publishing Co., 1958) has a distinguished board of editors drawn from the Netherlands, France, Germany and Great Britain. The first number contains nine papers which formed part of a symposium on "Insect and Foodplant" held at Wageningen in 1957. These interesting papers cover a wide range of topics in insect physiology and biochemistry, ecology, behaviour and plant breeding; but they cannot be regarded as typical of the kind of papers the new journal will carry in the future. The intention is to provide a meeting-ground between experimental and applied entomology. Such problems as the resistance of crop plants to insects, diapause, phenology, biological control and resistance to insecticides are among those which may be expected to figure in future numbers. This journal will certainly serve a most useful purpose. It is well printed and produced on a rather small page measuring 6 in. by 9¼ in.

Worthing Museum

In 1956 work commenced on a complete representation of the collections in the Worthing Museum. During its fifty years history, the Museum's collections have undergone a shift of emphasis from natural history and folk material to archæology, a process which has increased rapidly in momentum in the past decade. This might well have been foreseen, since the South Downs near Worthing have been

occupied during every prehistoric period with the exception of the Palæolithic, and the activity of archæologists and archæological societies has brought an increasing yield of displayable material from which a connected and absorbing story can be told. Latterly, too, the Museum staff has undertaken excavations which have made valuable contributions to the prehistory of Worthing. The theme of the new displays, therefore, is the habitation of the South Downs and coastal plain of West Sussex. Small models and diagrams were prepared to assist in the presentation of an easily assimilated visual story, and three more ambitious models and reconstructions were designed to focus attention and hold the interest of the casual visitor. The first of these is a copy of the geological relief map of the Weald in the Geological Museum, South Kensington—the first copy to have been attempted. The second is a large-scale model of a room in the Roman villa at Bignor, originally made for the Festival of Britain Exhibition, and the third is a reconstruction of a Roman cist burial from Avisford, complete with grave furniture. On March 1, Dr. W. E. Swinton, of the British Museum (Natural History), opened the sections already completed, containing material of the periods from Palæolithic to Mediæval times. Cases have already been provided for a new geology bay, and work will commence shortly on a series of period rooms which will continue the sequence down to the nineteenth century.

Gas Chromatography Discussion Group

THE Gas Chromatography Discussion Group was formed in association with the Hydrocarbon Research Group of the Institute of Petroleum following the Symposium on Gas Chromatography in London, May 1956, and has the following objects: to promote interest in gas chromatography; to organize meetings devoted to gas chromatography; to compile and distribute gas chromatographic data. The expanding interest shown in the activities of the Group over the past year has necessitated some changes in the present organization. It is proposed to invite interested workers in the field to become members of the Group and to contribute to the planning and execution of its work in the future. The annual subscription will be 1 guinea, which will entitle members to vote at general meetings, attend the informal symposia organized twice yearly and receive such compilations of data or other information as may become available from time to time. The first annual general meeting will be held in London in the autumn of 1958 in conjunction with the next informal symposium. Further information can be obtained from the secretary, D. H. Desty, British Petroleum Co., Ltd., Sunbury-on-Thames, Middlesex.

Geological Society of Australia

THE following officers of the Geological Society of Australia have been elected for the year 1957–58: *President*, Prof. A. R. Alderman (Adelaide); *Vice-President*, Prof. R. T. Prider (Western Australia); *Hon. Secretary*, Dr. N. H. Ludbrook (Department of Mines, Adelaide); *Hon. Treasurer*, Dr. O. A. Jones (Queensland); *Hon. Editor*, Dr. M. F. Glaessner (Adelaide).

The Geological Society of Australia was formally constituted in 1952. Developing originally from informal groups of geologists, it has attained in its sixth year about 470 members and 130 associates. The Society is organized on a Federal and State basis with seven State Divisions. Plenary meetings of the Federal body are held with the meetings of the Australian and New Zealand Association for the Advancement of Science. Until permanent headquarters are established, the headquarters of the Society move after each meeting to the place of the next plenary meeting. The *Journal of the Geological Society of Australia* has been published annually since 1953; Vol. 4, part 2, and two parts of Vol. 5 are due early in 1958. Inquiries regarding subscriptions to the *Journal* should be addressed to the Hon. Treasurer, Dr. O. A. Jones, Department of Geology, University of Queensland, St. Lucia, Brisbane.

A Cytotaxonomic Study of *Carex*

Áskell and Doris Löve and Marcel Raymond have given a cytotaxonomic account of the *Capillares* section of *Carex* (*Canadian J. Bot.*, 35, 715; 1957). This section comprises nine distinct species, one of which (*C. boecheriana*) is raised to specific status in this paper. Three species include two distinct subspecies each; two varieties and three formæ are accepted for two species, respectively. The chromosome numbers of the taxa involved are $2n = 18$, 36, 38, 40, 54, 56 and 58. The authors point out that the chromosomes of *Carex* have a polycentric or diffuse kinetochore and that this explains the aneuploid variations in number known to be typical of the genus. Karyotypic analysis of the chromosome complements of the section *Capillares* revealed that in the basic diploid set of $2n = 18$ chromosomes, four units are long, ten are medium and about half the length of the long ones, while four are small and about half the length of the medium ones. This frequency of size classes is also met with in the plants with $2n = 36$ and 54 chromosomes. Those taxa with $2n = 38$, 40, 56 and 58 chromosomes show, however, such a deviation in the frequency of the size classes that it seems logical that these numbers have been produced by a secondary fragmentation of the chromosomes. On the basis of karyotypic analysis of this section and other groups of the genus, it is concluded that the primary basic number for the genus *Carex* in particular, and the family Cyperaceae in general, must have been $x = 5$, all other numbers having been derived mainly by fragmentation of chromosomes with a polycentric or diffuse kinetochore. This phenomenon of partial agmatoploidy is widespread in Cyperaceae, whereas complete agmatoploidy is typical of the closely related Juncaceae.

Spectrophotometric Study of Stars with High Velocities

MADELEINE CHOPINET has a paper with the title "Étude spectrophotométrique de quelques étoiles à grande vitesse", in *Publications de l'observatoire de Haute Provence* (3, No. 42; 1957), which analyses a number of spectra of stars taken with the 120-cm. Newtonian telescope at Haute Provence. The dispersion of this spectrograph with a flint prism was, unfortunately, rather low—about 50 A./mm. towards 3900 A. and 80 A./mm. towards 4400 A. All the photographs contained certain stars which were to be studied, together with several comparison stars. The deductions confirm the results of several other investigators, particularly of Keenan and Keller (*Astrophys. J.*, 117, 241; 1953). In the opinion of the author, however, they are not sufficiently characteristic to serve as criteria for stars with high velocities. She has searched the records of high-velocity stars the trigono-

metrical parallaxes of which are known; about 2,200 are given in Miczaika's list (*Astro. Nach.*, 270, 249; 1940) and fifty others elsewhere. The Russell diagram for these stars is compared to the diagram for about 650 normal stars in the vicinity of the Sun, for spectral types between *F*0 and *M*5. It appears that the branch corresponding to the main sequence for stars of high velocity is nearly 0·5 magnitude below that of the normal stars. The number of giants of both categories is too small to draw any conclusions about them.

1958 Waverley Gold Medal Essay Competition

The Waverley Gold Medal and £100 will be awarded for the best essay of about 3,000 words based on some recent scientific research or new development (whether the author's work or not), giving some indication of the scientific background, the experimental results and its potential application in industry. The essay should be written in a form that is clearly intelligible to a scientist engaged in another field or a director of an industrial firm. The essays will be judged for technical content by specialists in that field, for clarity of presentation and style. A second prize of £50 will also be awarded, and an additional prize, also of £50, for the best entry from a competitor under thirty years of age on July 31, 1958. The competition is open only to persons at present engaged in scientific work. Further information can be obtained from the Editor, *Research*, 4/5 Bell Yard, London, W.C.2. All entries must be received on or before July 31.

"Natural Gas in Scotland"

Referring to the article under this title in *Nature* of December 28, p. 1444, Mr. T. S. Ricketts writes: "The British Petroleum Co., Ltd., has pointed out that the Cousland anticline was not discovered by the D'Arcy Exploration Co., Ltd., but is a well-known feature of the geological maps published by H.M. Geological Survey and has been known for a very long time. It was first tested shortly after the First World War, when a small amount of gas was proved. Most of the present sub-surface knowledge of the Cousland anticline was obtained by test drillings by the D'Arcy Exploration Co. and the Anglo-American Oil Co. during the period 1937–39. It was at this time that the gas accumulation now being used by the Scottish Gas Board was discovered by the D'Arcy Exploration Co. The local crest maximum with the natural gas in it may have an east-to-west long axis, but the anticline runs north and south and not east and west".

University News: Belfast

The following appointments to supernumerary lectureships have recently been made in The Queen's University of Belfast: R. H. Buchanan (geography); J. F. Gracey and W. A. M. Gordon (veterinary science); J. Patton (agricultural bacteriology); Dr. C. E. Wright (plant genetics and plant breeding); Dr. A. M. Raven (agricultural chemistry); and Dr. A. G. Smith (botany). Dr. J. L. Douce has been appointed lecturer in electrical engineering.

London

Dr. Leslie Crombie, lecturer in organic chemistry at the Imperial College of Science and Technology, has been appointed to the University readership in organic chemistry tenable at King's College.

Announcements

The National Institute of Industrial Psychology has appointed Mr. J. D. Handyside to the post of controller of research, with effect from April 1.

Dr. Ethelwynn Trewavas has been appointed a deputy keeper in the Department of Zoology, British Museum (Natural History). She has been a member of the scientific staff of the Museum since 1935 and is a leading taxonomic ichthyologist, her special study being freshwater fishes.

Mr. J. D. Alston, a well-known Norfolk farmer, has been appointed a member of the Agricultural Research Council, to fill a vacancy on the Council. Mr. David Lowe, a member of the Council since 1954, has been appointed deputy chairman in succession to Prof. S. J. Watson; Prof. Watson will continue to serve as a member of the Council and as chairman of the Council's Standing Committee on Research affecting Plants and Soils.

The Physical Society is holding a conference on "Spectroscopy of Solids" at the Royal Radar Establishment, Malvern, on May 28 and 29. Further information can be obtained from the Secretary, Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

The eleventh Brookhaven symposium in biology will be on "The Photochemical Apparatus: its Structure and Function". It is sponsored by the Biology Department, Brookhaven National Laboratory, Associated Universities, Inc., Upton, New York, and will be held during June 16–18. Further information can be obtained from Dr. R. C. Fuller at the above address.

The seventeenth meeting of the European Federation of Chemical Engineering will be a joint symposium on "The Organization of Chemical Engineering Projects". It will be held at Olympia, London, during June 24–26. Further information can be obtained from the Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1.

A symposium on "Continuous Cultivation of Micro-organisms", sponsored by the Institute of Biology of the Czechoslovak Academy of Sciences, will be held during June 23–28 in Prague. The symposium will deal with some theoretical aspects of continuous cultivation and the possibilities of the practical applications of this method. Further information can be obtained from Academician I. Málek, Institute of Biology, Czechoslovak Academy of Sciences, Na cvičišti 2, Praha 6, Czechoslovakia.

Dundee Technical College offers two one-week special summer programmes to bring information on electronic data processing methods and developments to those who are or may be involved in selecting, programming, operating or managing electronic computers. These are "Electronic Computers and Business Problems", to be held during June 23–27, and "Developments in Electronic Data Processing for Business", to be held during June 30–July 4. Both programmes will be directly supervised by Dr. Robert H. Gregory, professor of accounting, Massachusetts Institute of Technology, assisted by Dr. Stanley Gill, head of the Computing Research Group, Ferranti, Ltd., England. Further information can be obtained from the Head of the Department of Management Studies, Dundee Technical College, 40 Bell Street, Dundee.

HEALTH AND SAFETY IN THE ATOMIC ENERGY AUTHORITY

THE report of the Committee appointed under the chairmanship of Sir Alexander Fleck to review the organization of the Atomic Energy Authority as a whole for the control of health and safety* begins by describing the measures which the Committee considers essential. Safe technological practice, it believes, involves: (*a*) formulating codes of practice for design and operation based on experimental facts and experience; the special problems of nuclear energy require that preparation of the codes should be the responsibility of specialist health and safety staff; (*b*) designing plant using these codes of practice; this is the responsibility of design engineers; (*c*) operating and maintaining the plant to these codes; the executive responsibility for this rests with the works general manager and his operating staff; (*d*) overall monitoring of both design and operations by the safety staff, whose duty it is to direct the attention of the executive authority to any lapse from the prescribed codes.

The report next considers the functions of Government departments in this field and, after defining the Authority's role in relation to health and safety measures, the Authority's organization against this background. The national implications of the acute shortage of specialist health and safety staff in the field of nuclear energy to which the report directs attention, and the recommendations of the Committee in this connexion, and in regard to the Authority's external relations and responsibilities, are discussed elsewhere (p. 1023 of this issue). The internal recommendations are summarized below.

The Fleck Committee endorses the Authority's decision to establish a committee of the Atomic Energy Executive to be responsible for the overall supervision of all matters of health and safety, but recommends some minor changes in the terms of reference. It considers that the new committee structure established under the Executive Committee on Health and Safety provides an effective means of controlling health and safety throughout the Authority. Recommended terms of reference for the subordinate Weapons Safety Executive Committee, Safety Executive Committee and Health Executive Committee are suggested. It also recommends that the management of health and safety in the factories of the Industrial Group should be fully integrated into a single section responsible directly to the works general manager and endorses the new health and safety organization at Risley and the concept of an Authority Safety Branch which it contains. This organization, it is suggested, should be brought up to strength as a matter of urgency, and detailed terms of reference for the Industrial Group Health and Safety Branch are suggested covering the preparation of codes of practice, and provision of a medical service, radiological safety service and industrial safety service at each site, and provision of an independent inspection service.

The Committee recommends that there should be one senior member of the scientific staff at the Radiochemical Centre, whose principal duty would be functional responsibility to the manager for all safety matters. Existing members of the staff should be given this duty on a rota basis, and a first task of the new safety officer should be to investigate storage arrangements for radioactive materials. It is also recommended that the Authority should bring the site emergency procedures in each of its establishments to a uniformly high standard. The procedures should be co-ordinated to ensure that the maximum technical resources of the whole Authority may be deployed to counter an emergency in any single establishment. Finally, there should be closer collaboration between the Authority's three Groups on the problems concerned with the control of criticality, and each Group should have a nominated officer to bear functional responsibility for criticality problems.

* Atomic Energy Office. Report of the Committee appointed by the Prime Minister to examine the Organisation for Control of Health and Safety in the United Kingdom Atomic Energy Authority. Pp. 28. (Cmnd. 342.) (London: H.M. Stationery Office, 1958.) 1*s.* 3*d.* net.

INDUSTRIAL HEALTH IN GREAT BRITAIN

THE annual report* of the Chief Inspector of Factories for 1956 records a reduction of 2 per cent in the number of accidents, from 163,332 in 1955 to 160,116, although the estimated number employed in factories increased by 0·4 per cent. The downward trend in the accident rate per thousand employed continued, as did the fatality rate per million employed (54), the number of fatal accidents in factories being 426; and of 184,785 accidents notified during the year from all premises subject to the Factories Acts, 687 were fatal. The Chief Inspector observes that probably greater efforts have never been made than during the past year to reduce the risk of accidents due to fire, and these efforts, which are part of a continuing campaign carried out by the inspectorate, other Ministries, local authorities, fire services and various organizations, have been intensified, and co-operation between the authorities and services has been strengthened and extended.

The cardinal importance of the contribution of the scientist and technologist to health and safety in industry is again apparent from this report. Thus, reviewing progress on safety, the report stresses four aspects, in all of which that contribution is decisive. First, the need to design for safety. Secondly, the tendency for electrical and electronic apparatus to be included where formerly reliance was placed only on a mechanical system of control. Thirdly, and in consequence, greater reliability is required of such apparatus to ensure the safety of operators, since

* Ministry of Labour and National Service. Annual Report of the Chief Inspector of Factories for the year 1956. Pp. 195. (Cmnd. 329.) (London: H.M. Stationery Office, 1958.) 9*s.* 6*d.* net.

failure may lead to unexpected and dangerous movement. Accordingly, extensive studies are being undertaken of the reliability of complex electrical and electronic equipment, and there is every expectation that, in future, fault-finding will be made to some extent automatic, so that the production process may be kept going with a minimum of costly interruption. Fourthly, the problems of safety in the nuclear power stations are briefly reviewed (see p. 1023 of this issue).

There has been steady improvement in all fields of safety, and the Chief Inspector believes that accident prevention is gaining momentum, but that we need to set our sights a good deal higher. In referring to training in safety, he expresses the hope that the technical colleges will take greater interest, and that in the expanded programmes a place will be found for spreading the fundamental principles of safe working. The Clean Air Act, where it reduces the pollution of the atmosphere, has immediate repercussions on standards of cleanliness and lighting, and the Food Hygiene Regulations, 1955, have stimulated both food-products factories and factory canteens to further effort in cleanliness, both general and personal. Work continued on the surveys initiated by the Industrial Health Advisory Committee into conditions affecting health, and that on the Halifax Survey was practically completed during the year.

At the end of 1956, some 362 factories, including five receiving depleted uranium oxide from the Industrial Group of the Atomic Energy Authority at Risley, were receiving radioisotopes from Harwell and the Radiochemical Centre, Amersham, compared with 300 at the end of 1955, the most extensive use being for γ-radiography of castings, welds, etc., chiefly with iridium-192 and cobalt-60, though cæsium-137 continues to gain in favour. A draft code of regulations for the use of radioactive materials (other than for luminizing) was examined by an expert committee, and as a result draft regulations in respect of sealed sources were nearly complete by the end of the year and have since been published. The Radiological Protection Service made a concerted drive, with the Factory Inspectorate, to improve still further the protection of radium luminizers. The use of radioactive material for the elimination of static electrical charges continues to increase slowly.

SCIENTIFIC AND TECHNICAL TRANSLATION

A CONFERENCE on "Scientific and Technical Translation", organized by Aslib, was held at the Connaught Rooms, London, W.C.2, on March 5. Dr. J. E. Holmstrom of Unesco and Mr. E. B. Uvarov were chairmen for the morning and afternoon sessions respectively and about two hundred visitors attended. Mr. L. Wilson (director of Aslib) and Dr. Holmstrom introduced the subject, indicating that it had been examined in a report by Unesco* and was of increasing importance in facilitating scientific communication. Even if the problem were restricted to that experienced by those speaking English, it was found that about half of the world literature was unintelligible without translation. For those with other mother tongues the difficulties were far worse. The Unesco report contains the bulk of the factual information now available on translating methods, services, costs and indexes.

Three papers were presented: "The Organization and Availability of Technical Translation", by Dr. A. L. Mackay (Birkbeck College, London); "The Economics of Translation", by Mr. Felix Liebesny (Mond Nickel Company); and "Training for Translating Work", by Mr. A. G. Readett (National Coal Board, vice-chairman of the Institute of Linguists).

Dr. Mackay surveyed possible and actual methods of organizing the extraction of information from foreign-language literature, translation being regarded as an unproductive activity to be avoided if possible. The inefficiency of making a translation for one person who found only a fraction of it informative could be mitigated by circulating translations widely, regular cover-to-cover translations of major periodicals being the most systematic way of sharing expenses. Indexes of individual translations were thought to be only marginally useful. Persons properly qualified for scientific translation work would be better employed as full members of research and development groups working with linguistic and library rather than, say, chemical techniques. Material for translation should be selected for its value, reviews, digests and books being preferred; and an estimate of the premium to be placed on rapid processing could be made by attaching half-lives to various categories of literature. Training students in languages and maintaining scientific representatives abroad could reduce the volume of translation necessary.

Mr. Liebesny examined the actual costs, to an organization using translations, of various methods of preparation. He found that, where a complete text was required, the cost of translating a 1,000-word article from Russian to English was about 50*s.* to 120*s.*, depending on particular techniques (use of recorder, typist, etc.) and salary rates. If the translator worked through the paper orally with the inquirer, translating only part, the cost could be reduced to 17*s.* to 28*s.* Mechanical translation, according to the most optimistic forecasts, might cost 2*s.* per thousand words. Under various co-operative schemes, such as that run by the Department of Scientific and Industrial Research, where the costs are shared, the charges might vary from 8*s.* to 30*s.* For cover-to-cover translations of periodicals the cost would be only 4*d.* to 6*d.*, so that even assuming that only 2½ per cent of the papers which had to be bought were actually required and worth translating, the cost per thousand words would still be only 13*s.* to 20*s.* For such co-operative translations the choice of material is not wholly under the inquirer's control and certain papers would still have to be dealt with individually.

Mr. Readett described how translators at the London office of the National Coal Board were trained to prepare abstracts, to make full translations and to provide interpreter services. Only professional linguists of honours degree standard were recruited and they were familiarized with the technology of the subject. The close and harmonious relations maintained with the Board's technicians were especially

* "Scientific and Technical Translating and Other Aspects of the Language Problem". Unesco, 1957; second edition, 1958. (H.M. Stationery Office.) 20*s.*

emphasized. Visits, lectures and films, such as instructional films on new machinery, were used in addition to background reading material to ensure that translators were familiar with the subjects of the papers they had to translate. Only the highest quality of written translation was produced but, for speed, when only one inquirer wished for a translation, the paper could be very satisfactorily examined orally by the translator and the subject specialist. The concept of a 'rough translation' as something cheaper and easier to make than proper translation was based on a misunderstanding of the translation process which was to understand first, and then to re-express in English. Many papers could be clearer in a well-expressed translation, but those papers which were obscure, because they were ill-written and ambiguous even to a specialist, imposed an intolerable burden on the translator.

In discussion, Dr. D. J. Urquhart (Department of Scientific and Industrial Research) supported an organized system of cover-to-cover translation as the only real answer to the situation, together with the widest possible use of English by scientific journals. There was general agreement with this and with the proposition that students should be trained in foreign languages, particularly Russian, if only to employ translators more effectively. It was recommended that those translating papers should notify the Aslib index when they begin a translation so that duplication might be avoided. Many enthusiasts spoke on various aspects of translation without expressing views which diverged seriously from those of the main speakers, except that many preferred that scientists should be trained in languages rather than that linguists should be taught technology.

It was resolved, on the initiative of Dr. Urquhart, that Aslib should be recommended to convene a further conference "to see what measures can be taken to make Russian scientific and technical literature available in English". The meeting also passed a resolution from Dr. Clason (Philips, Eindhoven) that the whole question of translation required fuller consideration by a three-day conference. Discussion was terminated with a resolution that the Unesco Report proposals, circulated with the conference documents, should be sent out to participants as a questionnaire, so that the opportunity of obtaining the opinions of those attending the conference should not be lost through lack of time. The papers and discussion will be published later in "Aslib Proceedings".

A. L. MACKAY

HIGH POLYMERS

THE Kelvin Lecture, delivered on February 6 to the Institution of Electrical Engineers by Sir Harry Melville, dealt with the chemical structure and physical behaviour of high polymers. After giving an account of the underlying principles, Sir Harry dealt with natural and artificial rubber, polyethylene, synthetic fibres and ion-exchange fibres. The lecture brought out very well the co-ordination of chemistry, physics and engineering in the field of high polymers, and showed to what a large extent materials of this kind are finding all kinds of uses, and how their properties may to some extent be controlled on the basis of theory.

The fundamental property of a high polymeric material is its high molecular weight, which may increase from upwards of 10,000 to values of the order of a million for linear molecules and indefinitely large values for non-linear systems. The molecules should consist of long chains of atoms to which side-chains are attached. The groups in these side-chains may be able to rotate freely or may be joined by cross-links. If the main chain contains double bonds, its members will be hindered from rotation. If the number of molecules in the chain is not very large, the chain may coil into a spherical shape, and rubber is normally in this form. In stretching the rubber, the chains uncoil under moderate tension. Unvulcanized rubber behaves differently and tends to crystallize on extension. Vulcanization puts in cross-links, which are not extensive enough to prevent uncoiling. In synthetic rubbers the aim is to produce chains not long enough to form crystallites, and a recent discovery by the British Rubber Producers Research Association consists in modifying the chemical composition so that the chains cannot form such crystallites.

Silicones have chains of silicon and oxygen atoms in repeating units with various groups attached to the silicon atoms. They vary from mobile liquids, the viscosity of which is only very little affected by temperature, to rubber-like solids.

Polyethylene is a linear chain of carbon atoms with hydrogen atoms attached when the polymerization is carried out at room temperature. At higher temperatures and high pressures the molecules have many branches attached to the linear chain, and this has an important effect on the properties. By exposure to high-energy radiation such as gamma-radiation, hydrogen atoms are removed from the chains, leaving free radicals, which join to give cross-links, forming a three-dimensional structure which at high enough temperatures decomposes rather than melts.

Synthetic fibres must have a high tensile strength. It is curious that among the strongest natural and synthetic fibres the tensile strength does not vary much. The strength is much less than that calculated for breaking the chemical bonds, and it is less than the calculated value for other plausible structures, so that no explanation is yet known. The modulus of elasticity is close to the calculated value. The lecture dealt with the changes produced by altering the chemical composition. Fibres and rubber are closely related and relatively small changes in chemical structure influence their properties quite markedly.

Ion-exchange fibres are made by mixing high-polymer molecules containing carboxyl or acid groups and hydroxyl or alcohol groups, and heat treatment. They are in effect solid acids. In an acid liquid the fibre swells. If the acid is replaced by an alkali the molecules stretch, but if the fibre is put into acid its original state is restored. Theoretically, mechanical energy could be derived from such a system, but at present the efficiency is very low.

NEW INSTALLATIONS FOR B.B.C. TELEVISION

SINCE June 1955 a series of Engineering Monographs* has been published by the B.B.C., dealing with technical subjects within the field of television and sound broadcasting. Each Monograph describes work carried out by the Engineering Division of the Corporation and includes, where appropriate, a survey of earlier work on the same subject. About six Monographs are produced each year.

Monograph No. 12 is entitled "An Improved 'Roving Eye'", by T. Worswick and G. W. H. Larkby, and it describes the new design of mobile television camera which, with its associated equipment and short-range radio-link transmitter, permits pictures and their sound accompaniment to be broadcast while the vehicle is in motion and unimpeded by any connecting cables. The vehicle is equipped with two cameras, one of which gets a direct view forward through the windscreen or at right-angles to take kerbside interview shots. The second camera is mounted on a machine-gun ring and can be elevated with its operator to a position well clear of the roof. With this arrangement the camera can be swung to look all around the vehicle; and it can also be tilted on the mounting to take steep downward shots, for example to look on the pavement or in shop windows. The sound and vision signals are transmitted to the broadcasting network by a radio link on a frequency of about 660 Mc./s. When the vehicle is 'roving', a short aerial a few feet high is used to enable the van to pass under bridges; and in this case the maximum distance from the receiving base is some two or three miles. The vehicle is, however, also provided with a 45-ft. pneumatically operated telescopic mast, which can be used from a fixed position to send the signals over a distance of ten to fifteen miles from the receiving base. The normal crew of the vehicle comprises a driver, two cameramen, two operators, a commentator and producer; and the equipment is complete with an engine-driven alternator for the power required by the cameras, control units and the radio transmitter.

The two succeeding Monographs describe the premises at Hammersmith which the B.B.C. has recently converted into a self-contained television studio centre. No. 13 is entitled: "The B.B.C. Riverside Television Studios: The Architectural Aspects", by E. A. Fowler. It describes in some detail, with appropriate drawings and photographs, the planning and construction of the two studios, occupying 6,000 and 4,200 sq. ft., respectively, together with all the necessary equipment and facilities for the staging and production of television programmes. The incorporation of many new features on the engineering side, particularly in the fields of lighting control and co-ordination of the production and engineering staffs, has been made possible by the careful planning and layout of the studios and their auxiliary areas.

The technical accommodation and equipment are described in more detail in Monograph No. 14, entitled: "The B.B.C. Riverside Television Studios: Some Aspects of Technical Planning and Equipment", by H. C. Nickels and D. M. B. Grubb. As in the former case this number is well illustrated with plans, diagrams, photographs showing the studios, control rooms and associated lighting, camera and telecine equipment. The Riverside Studios represent the latest and most modern practice in the equipment of television studios in Britain: while they include certain novel features, they are essentially the outcome of experience gained over a considerable number of years.

* Obtainable from B.B.C. Publications, 35 Marylebone High Street, London, W.1. 5s. each, 20s. per year.

THE PHYSICAL SOCIETY DURING 1957

THE 1957 Year Book of the Physical Society (pp. iv+132. London: The Physical Society, 1957. 12s. 6d.) is the third in the annual series and contains the report of the Council of the Society for 1956; the proceedings of the meetings of the Society; obituary notices of five fellows, including Sir Francis Simon and Sir John Townsend; and the texts of the presidential address and of the special lectures and discourses delivered to the Society during the year.

The presidential address, entitled "The Physics and Chemistry of Metals", was delivered by Prof. N. F. Mott on June 4, following the annual general meeting of the Society (see *Nature*, **180**, 272; 1957). The forty-first Guthrie Lecture, given by Prof. H. C. Urey on April 9 during the spring meeting of the Society at the University of Nottingham, was originally entitled "Some Chemical Limitations on Theories for the Origin of the Solar System". However, Prof. Urey has since been able to study the interesting observations of E. K. Gerling and L. K. Levskii made in 1956 in the U.S.S.R. and he has consequently modified and added many points and details to his lecture, with the result that the revised text appears under the title "Meteorites and the Origin of the Solar System". Prof. Urey points out that though meteorites have been investigated by chemists and mineralogists for more than a century, since the Second World War new and modern techniques have been applied to the problem, and he proceeds to review both the older and more recent data, and to outline possible series of events which may have led to the formation of meteorites. Recent work on radioactive dating methods, it is stated, shows conclusively that a most involved series of chemical and physical processes took place some 4·5 aeons ago (an aeon is 10^9 years) during the period in which the solar system originated.

In the nineteenth Thomas Young Oration which he delivered on May 15, Dr. J. Guild, of the National Physical Laboratory, describes observations on the behaviour of diffraction gratings, dealing particularly with those properties which affect image formation. Following a description of the test-bench employed at the Laboratory for the examination of the gratings, a number of examples are given of the peculiarities of behaviour of typical diffraction gratings of various origins as revealed by the tests. The examples show

that the best gratings, regarded as optical instruments, are of poor quality by the standards normally applied to plane or concave reflectors, thus leaving considerable room for improvement in the technique of their production.

The magnetic refrigerator for temperatures below 1° K. was the subject of the thirty-third Duddell Medal address given by Prof. J. G. Daunt. A shortened version of the address (for the full text see *Proc. Phys. Soc.*, B, **70**, 641 ; 1957) is included in the Year Book, together with the thirty-fourth Duddell Medal address on the scale-of-two counter by Dr. C. E. Wynn-Williams ; the twelfth Charles Vernon Boys Prize address on "Hyperons and K-mesons : a Survey of the Results of the First Decade" by Prof. G. D. Rochester and Dr. C. C. Butler ; the thirteenth Charles Vernon Boys Prize address by Dr. L. Essen on the measurement of the velocity of light ; and the three evening discourses delivered at the forty-first Physical Society exhibition of scientific instruments and apparatus during March 25–28.

S. WEINTROUB

PUBLIC HEALTH TRAINING OF GENERAL PRACTITIONERS

IN many countries, general practitioners are required, in addition to their private practice, to devote part of their time to public health activities. They are thus called upon to play an important part in the protection of public health—a role for which they have not always received adequate training. A conference* to discuss this problem was organized by the World Health Organization in October and ovember 1956.

NThe main tasks of the conference were to examine the reasons for the frequent indifference of general practitioners to public health questions, to seek a means of arousing their interest in them, and to establish certain general principles for the guidance of those responsible for the organization of the public health training of general practitioners.

It was agreed that the first cause of indifference is in the present university and post-university curricula, which lay the main emphasis on diagnostic and therapeutic aspects. This is a gap which has to be bridged if the general practitioner is to be able to fulfil his public health role efficiently. Another reason for the lack of interest is that the young medical graduate finds the prestige and material compensations of private practice more attractive than public health work.

If the general practitioner's interest in public health work is to be aroused, the health authorities have to keep him informed of their plans for collective activities, and—whenever possible—invite his participation. For his part, the practitioner should realize that, even from the point of view of individual therapeutic care, there are advantages in having a modern public health service at his disposal.

There are various ways of maintaining effective liaison between the health administration and general practitioners, including periodic health bulletins, personal contacts and organization of meetings. Courses and seminars in which general practitioners are invited to participate are particularly helpful, and in several countries excellent results have been obtained by international teaching teams which have organized lectures and discussions in hospital centres on public health.

The report examines in detail the organization of courses for part-time public health medical officers and the various related problems, including time and place of courses, selection of teachers, content and arrangement of syllabuses. If physicians are to become familiar with the nature and aims of public health activities, if they are to take as much interest in these as in other aspects of their profession, and if they are to acquire the necessary technical competence, training programmes should cover, among others, the following subjects : role of the physician in society ; role of the public health administration ; reciprocal collaboration ; epidemiological methods ; environmental sanitation ; importance of external services (social services) ; and the interrelationship of curative and preventive medicine.

* World Health Organization. Technical Report Series, No. 140. Pp. 21. (Geneva : World Health Organization ; London : H.M. Stationery Office, 1957.) 1 Swiss franc ; 1*s.* 9*d.* ; 0.30 dollars.

SENSORY DEPRIVATION AND THE CAT'S OPTIC NERVOUS SYSTEM

By DR. LAWRENCE WEISKRANTZ
Psychological Laboratory, University of Cambridge

THAT rearing in darkness of rabbits[1], cats[2] and chimpanzees[3] can produce severe behavioural impairment in visual tasks is now well established. Less certain is whether this impairment can be attributed to peripheral neural changes, to the lack of opportunity to learn how to see—reflected, presumably, in neural changes limited to more central loci—or to both these factors.

The present investigation was undertaken to examine carefully the visual system of cats reared in darkness. The rearing was intentionally designed to conform to the schedule of an earlier study by Riesen, Kurke and Mellinger[2]. The five experimental animals were put into a dark room from the age of 7 days (before their eyes were opened) until they were 17 weeks old. From their fourteenth to seventeenth weeks, they were given a daily ½-hr. run in a normally illuminated room. During this period, the left eye of each animal received only diffuse illumination. This was achieved by fitting the animal with a mask with a semi-translucent insert in front of the left eye. The right eye received normal unobstructed stimulation. Riesen, Kurke and Mellinger found that cats reared in this manner not only had difficulty in

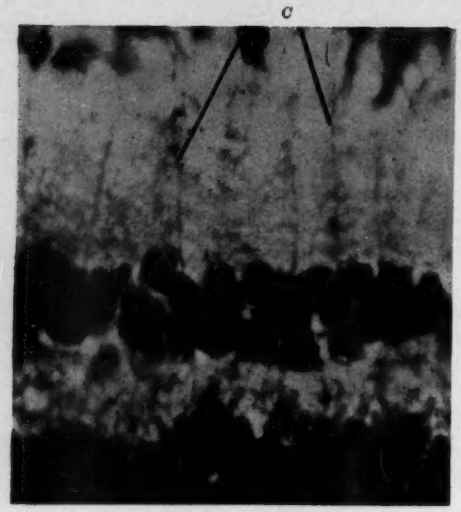

Fig. 1. Photomicrograph of the retina of a cat. *A*, inner plexiform layer; *B*, inner nuclear layer; *C*, Müller fibres. (× *c.* 450)

learning pattern discriminations with either eye, but had a deficit in transferring habits learned with one eye to the other eye. I observed, similarly, that the cats were severely impaired in discriminating objects and depth during their runs, although since my animals were killed at the end of the 17-week period there was not time to carry out the extended behavioural procedures which would be required for a complete replication of the earlier study, particularly those aspects concerned with interocular transfer.

The five experimental kittens were litter mates. As it was not practically possible to have matched or litter-mate controls, an attempt was made to obtain a fairly wide range of ages of control animals. At the time of death these ages were 10, 13, 18, 18 and 75 weeks (the last being the mother of the experimental kittens). The control cats were kept in well-lit laboratory rooms in cages identical to those of the experimental animals. The experimental kittens were 17 weeks old at the time of death.

All animals were killed with coal gas, and the eyes and optic nerves fixed in Bouin's solution. The brains were fixed in formol. The eyes and nerves were eventually embedded in 'Celloidin', the brains in paraffin. A variety of staining procedures were employed.

In microscopic examination of the retinas, no differences between controls and experimental animals were immediately obvious. After considerable examination, however, the impression was gained that there were some differences of a statistical or relative nature rather than all-or-none. In particular, experimental retinas seemed to have fewer clearly stained fibres transversing the inner plexiform layer, particularly Müller fibres. In addition, the inner plexiform layer appeared to be relatively thinner in the experimental retinas. Measures of these two features, therefore, were obtained. Molybdic acid hæmatoxylin was found to be the most suitable stain for both purposes. The sections were 10μ thick.

Before measuring the thickness of the inner plexiform layer, the slides were coded by an assistant so that it was not evident which was control and which experimental. Four specified points on each of two slides for each of the twenty eyes were used. The slides were chosen at random, the only restriction being that the sections had to be cut through the blind spot. The thickness of the over-all retina, the inner plexiform layer, and the inner nuclear layer was measured under high-power oil immersion (Fig. 1). Upon decoding and averaging, the distribution shown in Fig. 2 was obtained. The inner plexiform layers in the experimental eyes were thinner than those in controls. This was true both in absolute terms and in terms of the thickness relative to the over-all retina. The latter was about a 15 per cent difference, on the average, and was significant at the 1 per cent level by the Mann–Whitney non-parametric test[4]. There was some tendency for the retinas of control animals to be thicker over-all than those of experimental animals (Fig. 3); but this was not marked nor statistically significant. There was no suggestion of a difference in the relative thickness of the inner nuclear layer (Fig. 4). These measurements were repeated by another member of the laboratory, with comparable results.

Müller fibres were counted in two sections of each retina, the only condition being, again, that the sections had to include the blind spot. Under oil immersion, every recognizable fibre which travelled at least half the distance from the ganglionic layer through the inner plexiform layer was counted. The sections were not coded. The fibre counts were converted into density measures (fibres per unit length) since there was considerable variation in the actual retinal perimeters. The results are shown in Fig. 5. The experimental retinas are about 20 per cent less dense in the populations of Müller fibres than the controls. This difference is also significant at the 1 per cent level by the Mann–Whitney test. (Actually, 'Müller fibres' is certainly too broad a designation, since the count included a variety of fibre types. However, Müller fibres—so far as it is possible to identify them on the basis of the usual descriptions of them—certainly dominated.)

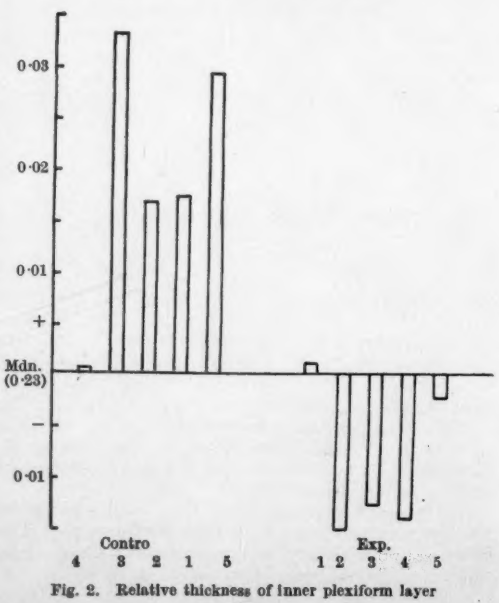

Fig. 2. Relative thickness of inner plexiform layer

No significant difference between the right and left retinas of the experimental animals could be found in the above measures. No differences in the size or distribution of ganglion cells appeared between groups or between left and right experimental eyes.

Finally, density measurements were obtained of fibres in the optic tract. Glees silver stain was used, with control and experimental brains embedded in the same block, sectioned and stained together. This was done as control, for variation is often characteristic of silver stain. Each tract on each side of each brain was sampled at twelve designated positions and fibres crossing a particular grid line under high-power magnification were counted. Experimental tracts were compared only with the corresponding control tracts on the same section. Out of nine such comparisons (one comparison was impossible to make because of poor staining), control tracts were more dense than experimentals in eight cases. Such a difference is significant at the 5 per cent level by simple binomial analysis. The amount of the difference was small, averaging about 6 per cent.

Chow, Riesen and Newell[5] have recently published a study of retinal changes produced by rearing chimpanzees in the dark. They found almost complete

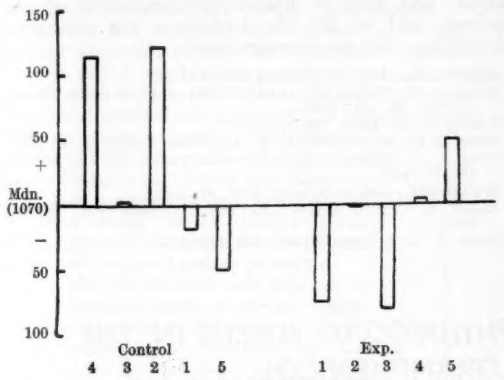

Fig. 3. Relative thickness of retina

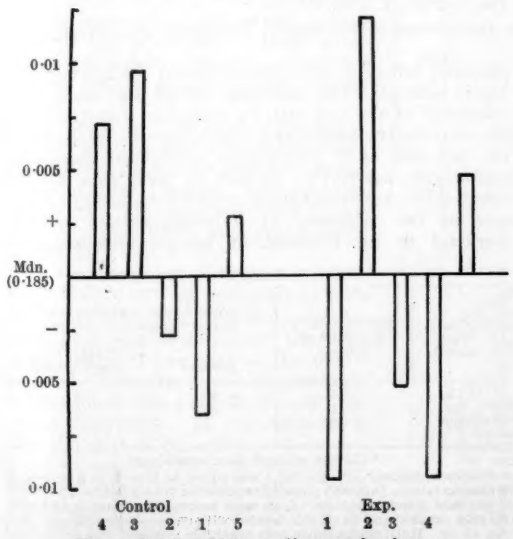

Fig. 4. Relative thickness of inner nuclear layer

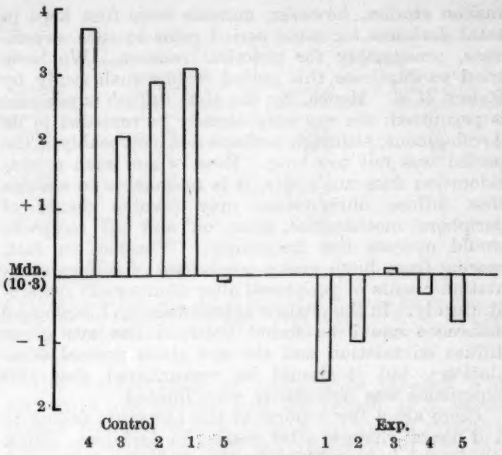

Fig. 5. Density of Müller fibres

disappearance of ganglion cells in the case of two animals kept in darkness for 1½ and 2½ years. A 'normal' retina was found for a third chimpanzee reared in the dark for 7 months, with limited daily experience of non-patterned stimulation, and which was afterwards brought out into the light for two years. But these investigators do not report any control material, and give no basis for assuming that this third retina was in fact entirely normal. Nor is it known, of course, whether it was not more obviously abnormal when the animal was first brought out into the light.

Brattgård[6] has reported an elegant study of the pentose nucleoprotein fraction of retinal ganglion cells of rabbits reared in darkness. It was found that 10 weeks of darkness from birth yielded a pentose nucleoprotein fraction of zero. Animals afterwards brought out into the light did not develop pentose nucleoprotein as rapidly as did controls. To quote his conclusion, "The cell is dependent on adequate stimulation for the continued development of the nucleoprotein fraction. If it is deprived of this stimulation, the production is reduced or inhibited" (p. 67).

Thus, there seems little doubt that retinal ganglion cells are implicated; but the questions of the time-course and the sequence of events remain to be settled. Chow, Riesen and Newell have considered abnormal only the instance of rather complete disappearance of ganglion cells—a somewhat advanced state. Brattgård found ganglion cells well developed in terms of conventional histological examination, but altered in cell chemistry, in rabbits reared in darkness for 10 weeks. My cats, after 17 weeks of darkness, showed normal ganglion cell bodies, by conventional histological examination, but altered cell processes. That is, the inner plexiform layer, which includes the dendrites of the ganglion cells, was thinner, and the optic tract, which includes the axons of the ganglion cells, was less dense. The significance of the difference in Müller fibre density may be related to Brattgård's results, since one of the functions ascribed to the Müller fibres by some authorities (for example, Polyak[7]) is a metabolic one.

Attempts have been made to avoid the suspected peripheral atrophic reactions by rearing animals in diffuse, non-patterned light. In many such mam-

malian studies, however, animals were first kept in total darkness for some period prior to such experience, presumably for practical reasons. We have tried to duplicate this period in one such study by Riesen *et al.* Hence, by the time diffuse experience is permitted, the eye may already be retarded in its development, although perhaps not irrevocably if the period was not too long. Even where such a consideration does not apply, it is reasonable to assume that diffuse illumination may involve disuse of peripheral mechanisms, since 'on' and 'off' receptors would operate less frequently. Whether, in fact, rearing from birth under conditions of diffuse stimulation results in peripheral alteration awaits systematic study. In the present experiment, no histological difference could be found between the eye given diffuse stimulation and the eye given normal stimulation; but it should be remembered that this experience was necessarily very limited.

There are a few reports in the literature failing to find neural changes after rearing in darkness. Thus, Goodman[1] kept rabbits in the dark for 6 months, producing a clear behavioural deficit for vision. Unfortunately, data are not presented for the thickness of the inner plexiform layer of the retina, but only for the combined thickness of the optic fibre, ganglion cell, and internal plexiform layers, taken together. Nevertheless, this combined figure is smaller in experimental than control retinas. No counts of the optic tract are reported. But the density of cells in the superior colliculi of experimental brains was slightly greater than in control brains, as was, also, the density of pyramidal cells in the striate cortex. Both findings are consistent with a general notion of reduction of fibre field density. Interestingly enough, the lamina molecularis of the striate cortex, which is almost exclusively a fibre layer, was slightly thicker in controls than in experimental animals. All these differences are admittedly slight; but, since only group averages are reported, it is impossible to apply statistical treatment. The direction of the differences would, in general, support my findings.

Chow[8] kept two monkeys in total darkness for 8 months. The only retinal measure reported, however, was the density of ganglion cells, which did not differ from the control figures. There was no change in cell density in the lateral geniculate. Fibre counts are not reported.

It should be made clear that my findings do not rule out the hypothesis that sensory learning may occur as a necessary part of development. They merely cast doubt on the use of total sensory deprivation as a method of testing the hypothesis. While it might be convenient for psychological theory for sensory deprivation to produce changes limited to central neural structures, it is not convenient, perhaps, for the nervous system itself to make such a distinction.

This work was begun in the University Laboratory of Physiology, Oxford. My thanks are due to Prof. E. G. T. Liddell for the use of facilities and animals, to Messrs. Leach and Chesterman for invaluable advice and help in histological processing of the retinas, and to Mr. R. Hutchison for assistance throughout the entire experiment.

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CELL-WALL SYNTHESIS BY *STAPHYLOCOCCUS AUREUS* IN THE PRESENCE OF CHLORAMPHENICOL

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DURING investigations of the effect of chloramphenicol on the level of free amino-acids within growing cells of *Staphylococcus aureus* (strain Duncan)[1] it was necessary to measure the rate at which synthesis of cell material in the presence of the antibiotic was responsible for removal of amino-acids from the internal pool. Since chloramphenicol at the concentration used (50 μgm./ml.) causes complete inhibition of protein synthesis (measured by increase in 5 per cent trichloracetic acid-insoluble L-glutamic acid) in *S. aureus*[2], it was surprising to find that the increase in hot-trichloracetic acid-insoluble nitrogen in the culture was only inhibited to the extent of 70 per cent (measured over a period of 1 hr.). It seemed possible that this increase in the presence of chloramphenicol represented synthesis of the hexosamine-peptide polymer which in many Gram-positive bacteria is the predominant component of the cell wall; in *S. aureus* this polymer contains two hexosamines, glycine, D- and L-alanine, L-lysine and D-glutamic acid[3,4]. Accordingly, in the experiment described in Table 1, cells grown for 60 min. in the presence of chloramphenicol (50 μgm./ml.) were analysed for hot-trichloracetic acid-insoluble nitrogen before and after solubilization of the cell wall by complete digestion with the enzyme lysopeptidase, which specifically degrades the cell wall of *S. aureus* and is without detectable proteolytic activity[5]. It can be seen that all the increase in hot-trichloracetic acid-precipitable nitrogen in the presence of chloramphenicol can be ascribed to an increase in lysopeptidase-sensitive

Table 1

Time (min.)	Optical density of culture at 700 mμ	Hot-trichloracetic acid-insoluble nitrogen (μgm./ml. culture)	
		Control	Treated with lysopeptidase
0	0·35	46	34
60	0·41	63	35
60*	0·69*		

* Culture without chloramphenicol

Chloramphenicol (50 μgm./ml.) was added at time 0 to a culture of *S. aureus* (strain Duncan) growing exponentially in 2 per cent peptone–2 per cent glucose medium. Cells were harvested at time 0, and after 60 min., washed and an aliquot treated with lysopeptidase (50 μgm./ml.) for 15 hr. Hot-trichloracetic acid-insoluble nitrogen was determined on treated and control samples.

* National Science Foundation Senior Post-Doctoral Fellow.

Table 2

Carbon-14 amino-acid	Total		Protein		Cell wall	
	Control (counts/min.)	Inhibition (per cent) + chloramphenicol	Control (counts/min.)	Inhibition (per cent) + chloramphenicol	Control (counts/min.)	Inhibition (per cent) + chloramphenicol
L-Leucine (2,900)*	5,135	92	4,917	98	234	95
L-Proline (6,650)	4,230	95	4,200	97	14	90
L-Phenylalanine (9,560)	7,170	94	7,050	94	58	92
Glycine (3,750)	24,400	37	8,700	90	15,700	8
L-Lysine (7,180)	31,400	71	21,050	96	10,350	6
L-Alanine (1,410)	8,700	54	4,320	85	4,300	5
L-Glutamic acid (8,100)	25,950	82	20,100	97	5,850	4
Increase in hexosamine (μmoles)	1·3	0	0	0	1·3	0

* Final specific activity, counts/min./μmole.

An equal quantity of an amino-acid uniformly labelled with carbon-14 was added to each of a pair of cultures of *S. aureus* (strain Duncan) growing exponentially in synthetic medium (ref. 1); chloramphenicol (50 μgm./ml.) was added to one flask. After 45 min. at 37° C., cells were harvested and fractionated as described. Samples were taken for radioactivity determinations using 'infinitely thin' samples, and hexosamine was determined by the procedure of Boas (ref. 6).

material, suggesting that under these conditions synthesis of cell-wall material continues although protein synthesis is completely inhibited.

Confirmation of this finding was sought using amino-acids labelled with carbon-14. A method developed in this laboratory was used for preparation of cell-wall fractions which allows rapid sampling, quantitative recovery and avoids the possibility of autolytic degradation during preparation. This procedure will be described in detail elsewhere; it entails extraction of cells with 5 per cent trichloracetic acid at 100° C. for 15 min. and digestion of the residue at 37° with trypsin (500 μgm./ml.) in 0·01 *M* ammonium bicarbonate (*p*H 8·0) until the optical density at 700 mμ ceases to drop; the residue is washed in ammonium bicarbonate and in 1 *N* ammonia. From the following evidence it appears that this fraction consists of all the cell-wall material contaminated with not more than about 5 per cent of cytoplasmic protein:

(*a*) After hydrolysis and separation of the amino-acids by paper chromatography, more than 90 per cent of the ninhydrin-reacting material is accounted for by alanine, glycine, lysine and glutamic acid, the characteristic amino-acids of *S. aureus* cell walls[3]. All the hexosamine of the cell, estimated by the procedure of Boas[6] after hydrolysis in 6 *N* hydrochloric acid for 5 hr. at 105°, is present in this fraction (Table 2).

(*b*) Less than 5 per cent of the radioactivity incorporated into growing cells from labelled non-wall amino-acids appears in this fraction, but between 22 per cent (glutamic acid) and 65 per cent (glycine) from wall amino-acids (Table 2).

(*c*) On treatment with lysopeptidase the turbidity of such preparations falls by 90 per cent, and from preparations containing carbon-14 in all the wall amino-acids 96 per cent of the radioactivity becomes non-sedimentable (3,000*g* for 30 min.) and 31 per cent becomes dialysable. It was considered that the ease of quantitative recovery and the small amount of contamination with cytoplasmic protein made such preparations suitable for studies of cell-wall synthesis.

The incorporation of amino-acids labelled with carbon-14 into the cell wall and protein of *S. aureus* (strain Duncan) during 45 min. growth in synthetic medium[1], together with the effect of 50 μgm./ml. chloramphenicol, is presented in Table 2. Considering the fraction insoluble in hot trichloracetic acid as a whole, the chloramphenicol-sensitive incorporation appears to be exclusively into the protein; incorporation into the cell wall is insensitive to chloramphenicol at this concentration (incorporation of alanine into the cell wall is unaffected by chloramphenicol at concentrations up to 500 μgm./ml.). Over longer periods some inhibition of wall synthesis is observed; this is probably because chloramphenicol prevents the

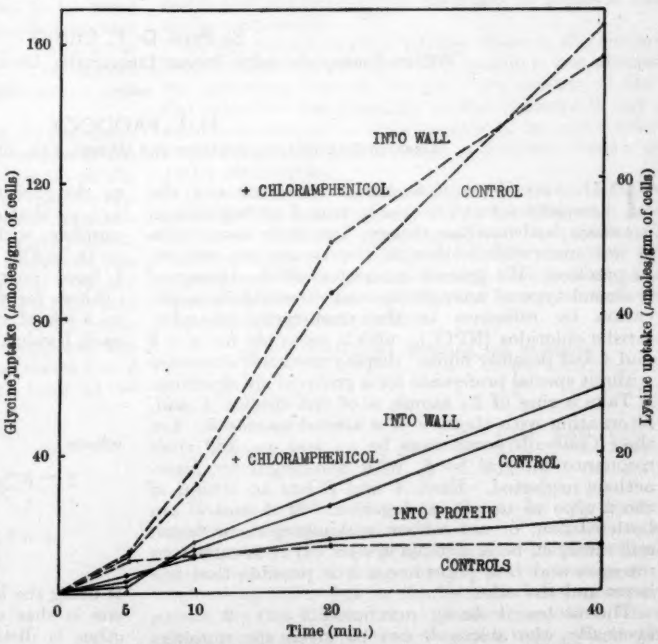

Fig. 1. Rate of incorporation of lysine (——) and glycine (– – –) into *S. aureus H*. Cells were harvested from nutrient broth when the cell population reached 0·5 mgm. dry weight/ml., washed, resuspended at a concentration of 1 mgm./ml., and shaken at 37° C. in the following medium which contained, per ml.: L-lysine, 0·5 μmole; glycine, 0·5 μmole; L-glutamic acid, 2 μmoles; DL-alanine, 2 μmoles; uracil, 20 μgm.; glucose, 4 mgm.; phosphate buffer, *p*H 7·0, 80 μmoles; magnesium sulphate, 1 μmole; manganese chloride, 0·1 μmole; thiamin, 2 μgm.; nicotinic acid, 1 μgm. Uniformly-labelled amino-acid (0·1 μc./ml.) was used and the cells were fractionated as described in the text

formation of the wall-synthesizing system so that wall synthesis is linear, compared with an exponential control. Moreover, the wall synthesized in the presence of chloramphenicol appears to be normal in at least two respects: the ratios of increases in glutamic acid : glycine : alanine : lysine : hexosamine were 1 : 5·8 : 4·2 : 2·0 : 1·8, compared with ratios of 1 : 6·3 : 2·8 : 1·9 : 1·8 in the wall present initially, and the extent of digestion by lysopeptidase (which is probably the result of a highly specific structure in view of the limited specificity of the enzyme[5]) was the same in wall synthesized in the presence and in the absence of chloramphenicol.

It has been found that *S. aureus* (strain *H*) will synthesize cell-wall material under conditions in which amino-acid incorporation into the protein fraction is severely reduced by the absence of essential amino-acids. As shown in Fig. 1, in the presence of L-lysine, alanine, glutamic acid, glycine, uracil and glucose, *S. aureus* (strain *H*) will almost double its wall in 40 min. as measured by the incorporation of lysine or glycine. The rate of synthesis of new wall material is linear, and chloramphenicol (20 μgm./ml.) has no significant effect on this synthesis.

Hence, in both growing cells and cells in which the synthetic activity is directed predominantly towards wall synthesis, chloramphenicol has no inhibitory effect on this synthesis. It is clear from these results that the fraction of bacterial cells insoluble in hot trichloracetic acid cannot be regarded as homogeneous with respect to the incorporation of labelled amino-acids, particularly in the case of the Gram-positive bacteria, where the hexosamine-peptide polymer may account for 30 per cent or more of the material insoluble in hot trichloracetic acid (Park, J. T., unpublished work). It is probable that hexosamine-peptide structural elements similar to those occurring in the Gram-positive cell wall are present also in the wall of Gram-negative bacteria, for example, *Escherichia coli*[7], but in smaller quantity; hence in all bacteria it is advisable to distinguish between amino-acid incorporation into the protein and that into cell-wall structures other than protein.

We are indebted to Dr. M. R. J. Salton for a preparation of lysopeptidase; this work was carried out during the tenure by one of us (R. H.) of a Medical Research Council Scholarship.

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A NOVEL TYPE OF AROMATICITY

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THE two ideas of aromatic character and the aromatic sextet are closely bound up together in aromatic hydrocarbon theory, but their association is not invariable, either in theory or, we believe, in practice. We present an outline of the theory of a second type of aromaticity and illustrate its application by reference to the monocyclic phosphonitrilic chlorides $(NPCl_2)_n$, which, certainly for $n = 3$ and 4 and possibly higher, display aromatic character without special preference for a group of six electrons.

Take a ring of $2n$ atoms, n of one species A and, alternating with them, n of a second species B. Let their Coulomb parameters be α_A and α_B, and their resonance integral be β, with non-neighbour interactions neglected. Each A and B has an orbital of the π-type to use in conjugation. If A and B are both carbon, or are carbon and nitrogen, or boron and nitrogen, both orbitals are $p\pi$. If A is carbon or nitrogen and B is phosphorus it is possible that one is $p\pi$ and the other $d\pi$.

The atoms A being numbered $k = 1, 2 \ldots n$ cyclically, the atoms B can be given the numbers $k + 1/2 = 3/2, \ldots n + 1/2$. Using molecular orbital theory of the simplest type, we begin with combinations of the sets A and B with irreducible symmetry:

$$A_l = n^{-1/2} \sum_{k=1}^{n} \exp(2\pi i l k/n)\, \varphi_k$$

$$B_l = n^{-1/2} \sum_{k=1}^{n} \exp\{2\pi i l\,(k + 1/2)/n\}\, \psi_{k+1/2}$$

φ_k denotes the π orbital at the kth centre, and $\psi_{k+1/2}$ that at the $k + 1/2$. l is the ring quantum number with allowed values $0, \pm 1, \ldots n/2$ or $\pm (n-1)/2$ for n even or odd. Pairs of the same l have now to be combined to form molecular orbitals for the system. This leads in the usual way to a set of second-degree secular equations, one for each l value, of the form:

$$\begin{vmatrix} \alpha_A - \varepsilon & \chi \\ \chi^* & \alpha_B - \varepsilon \end{vmatrix} = 0$$

where

$$\chi = n^{-1} \sum_k \exp(-2\pi i l/2n) \int \varphi_k \mathbf{H} \psi_{k+1/2}\, d\tau$$

$$+ n^{-1} \sum_k \exp(2\pi i l/2n) \int \varphi_k \mathbf{H} \psi_{k-1/2}\, d\tau$$

$\mathbf{H}$ being the hamiltonian. Two cases only can occur: one is that of the aromatic hydrocarbons, and the other is distinct but not, so far as we are aware, hitherto recognized as such. They are illustrated in Fig. 1.

For convenience in fixing signs each member of the A set is generated by successive n-fold rotations from the first, and likewise in the B set. Then in case (1) every atom interacts with both its neighbours in the same way, that is,

$$\int \varphi_k \mathbf{H} \psi_{k+1/2} d\tau = \int \varphi_k \mathbf{H} \psi_{k-1/2}\, d\tau$$

This holds when A and B use the same species of atomic orbitals, both $p\pi$, or both $d\pi$, and also under somewhat wider conditions, as, for example, when A and B use orbitals which have in common both π-character and character for a reflexion σ_v. In case (2) the interaction of an atom with one neighbour is the negative of that with the other,

$$\int \varphi_k \mathbf{H} \psi_{k+1/2}\, d\tau = -\int \varphi_k \mathbf{H} \psi_{k-1/2}\, d\tau$$

as illustrated for $p\pi - d\pi$ interactions in the diagram. This case only occurs when A and B use different species of atomic orbitals and not always then. The orbitals must differ in character under σ_v.

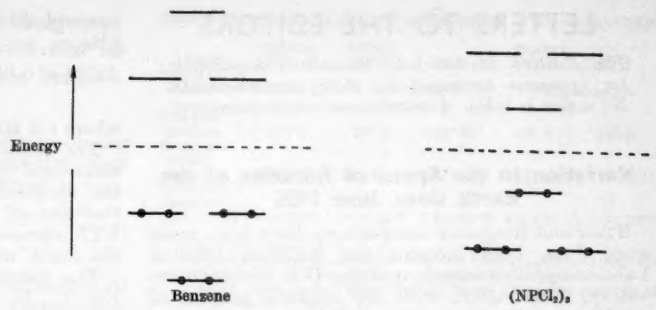

Fig. 2

Returning to the secular equation, for case (1) we find $\chi = \pm 2\beta \cos(\pi l/n)$, the sign depending on how the set of A orbitals is oriented, by initial choice, relative to the set of B. For benzene ($n = 3$, $\alpha_A = \alpha_B = \alpha$) this leads to the usual results for molecular orbital energies: $\varepsilon_0 = \alpha \pm 2\beta$, $\varepsilon_{\pm 1} = \alpha \pm \beta$ (both twice). In case (2) $\chi = \pm 2i\beta \sin(\pi l/n)$ leading to the energy expression

$$\varepsilon_l = (\alpha_A + \alpha_B)/2 \pm \{(\alpha_A - \alpha_B)^2 + 16\beta^2 \sin^2(l\pi/n)\}^{1/2}/2$$

For $n = 3$, $\alpha_A = \alpha_B = \alpha$, $\varepsilon_0 = \alpha$ (twice) $\varepsilon_{\pm 1} = \alpha \pm \sqrt{3}\beta$ (both twice). This example shows that the lowest energy is associated with ε_0 in case (1), with $\varepsilon_{\pm 1}$ in case (2); to be realistic we should allow α for the $2p\pi$ orbitals (for example, nitrogen) to be more negative than the $3d\pi$ (for example, phosphorus), and putting $\alpha_N = \alpha_P + \beta$ for purposes of illustration leads to the results shown in Fig. 2. The dotted line is placed at α_C for the benzene calculation and at $(\alpha_N + \alpha_P)/2$ for $(NPCl_2)_3$.

The differences between cases (1) and (2) run deep, but we wish now only to emphasize the matter of the aromatic sextet. The states $l = 0$ always lie at the extremes of the energy band in case (1), so that the top occupied orbital is always doubly degenerate in hydrocarbons. Closed shells associated with typically aromatic inertness therefore contain $4n+2$ electrons; $4n$ electron systems leave a half-filled orbital and are not aromatic. This is, of course, Hückel's rule, and the particular example of the stability of six compared with four and eight electrons supports the notion of the sextet. In case (2) the two states $l = 0$ have different symmetries and always (any n) lie adjacent to one another half-way up the energy band. Since except for exact equality in the electronegativity parameters of A and B these states are non-degenerate, a closed shell is obtained for any even number of electrons, both $4n$ and $4n + 2$. In the planar system in case (2) there is no preference for six over four or eight electrons, therefore no special stability is expected for a sextet. On the contrary, the energy per π-electron rises slowly but monotonically with the number of electrons to a limiting value, so that for planar molecules eight electrons are more stable than six. Fully in harmony with this is the fact that both the trimeric and tetrameric ($n = 3$ and 4) phosphonitrilic chlorides show unexpected stability and equal bond-lengths, both roughly speaking displaying equally well-developed aromaticity, in contrast to benzene and *cyclo*-octatetraene.

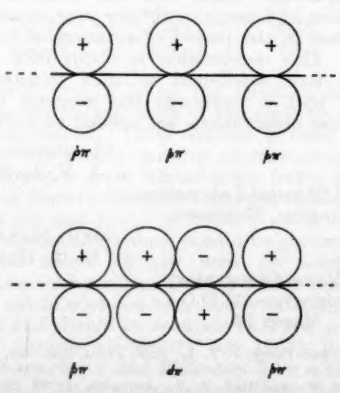

Fig. 1

In the phosphonitrilic halides there is the further consideration that the $p\pi - d\pi$ system is less affected by puckering than is the $p\pi - p\pi$ system, so that the probable non-planarity of the tetramer is not a serious hindrance to maintenance of aromatic interactions and need not affect arguments based on plane structures.

Conventional calculations of π-electron energies made for the case $\alpha_N = \alpha_P + \delta$, where δ is now used for the P–N resonance integral, are compared with the hydrocarbons in Table 1. Values are given per π-electron. We emphasize that the choice of α-values is an arbitrary one, and merely serves to indicate the pattern of the problem.

Table 1. Calculated Energies per Electron

No. of electrons	4	6	8	10	12
Aromatic hydrocarbons $\alpha_C +$	$1{\cdot}0\beta$	$1{\cdot}33\beta$	$2{\cdot}20\beta$	$1{\cdot}30\beta$	$1{\cdot}24\beta$
$(NPCl_2)_n$ $\alpha_P +$	$1{\cdot}78\delta$	$1{\cdot}87\delta$	$1{\cdot}89\delta$	$1{\cdot}90\delta$	$1{\cdot}90\delta$

The alternation of values shown by the hydrocarbons, corresponding to the $4n + 2$ *versus* $4n$ rule, is not shown by the phosphonitrilic halides. Both series approach limiting energies per π-electron with increasing size; but in the hydrocarbons successive members fall above ($4n + 2$ electrons) and below ($4n$), while in the second case the approach to the limit is always from below, showing that if π-electrons were the only consideration, bigger molecules would be favoured over smaller ones. These quantitative results are, however, secondary to the main point, which is the distinction between the two types of aromaticity; this distinction depends on symmetry and is independent of the more disputable quantitative features of π-electron theories.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Variation in the Speed of Rotation of the Earth since June 1955

Time and frequency comparisons have been made since June 1955 between the National Physical Laboratory, Teddington, and the U.S. Naval Observatory, Washington, with the ultimate purpose of establishing the value of the transition frequency of cæsium, (4,0) ⇌ (3,0), in terms of the second of Ephemeris Time based on the orbital motion of the Moon[1,2]. The second of Ephemeris Time is being determined at the Naval Observatory from photographic observations of the Moon, and will be reported on later.

As an intermediate step, the frequency of cæsium is currently being determined with respect to the second of Universal Time, called UT2, which is based on the rotation of the Earth. This frequency is denoted ν_U. The intervals between time signals from *WWV* (Washington, D.C., U.S.A.) and *GBR* (Rugby, U.K.) are measured at the National Physical Laboratory in terms of the cæsium standard, and at the Naval Observatory in terms of UT2. By using signals near the first of each month, the average frequency for the intervening month is intercompared with a probable error of 3 parts in 10^{10}.

If it is assumed that the time occupied by a specified number of vibrations of the National Physical Laboratory standard is constant, we may use it to determine changes in the speed of rotation of the Earth. Such changes would be indicated by changes in ν_U. The precision of the cæsium standard is so high that the accuracy with which the changes in speed of rotation can be determined depends almost entirely on the accuracy with which Universal Time can be determined. The results given here are based on observations made with the photographic zenith tubes at Washington, D.C., and Richmond, Florida, which are known to be instruments of high accuracy.

In order to interpret changes in ν_U, it is necessary to describe the types of variation in speed of rotation and how UT2 is computed.

There are three types of variation in speed: secular, irregular and periodic. The first, due to tidal friction, is too small to be significant here. Irregular variation refers to departures from the average speed of rotation which continue for the order of 5 or 10 years. This effect has been surmised but not previously exhibited. Periodic terms have been found with periods of 1 year, 0·5 year, 27·6 days and 13·6 days[3]. The first two of these terms comprise what is known as the seasonal variation.

By international agreement, an empirical correction for seasonal variation has been applied since January 1, 1956, in obtaining the time called UT2. The formula adopted by the Bureau International de l'Heure is:

$$\Delta SV = 0{\cdot}022^s \sin 2\pi t - 0{\cdot}017^s \cos 2\pi t - 0{\cdot}007^s \sin 4\pi t + 0{\cdot}006^s \cos 4\pi t$$

where t is the fraction of a year.

The terms of period 27·6 days and 13·6 days are eliminated by the smoothing process used in obtaining the adopted UT2 published in the *Time Service Bulletins* of the U.S. Naval Observatory. Hence, UT2 represents, in effect, the speed of rotation of the Earth when freed of periodic terms.

The values of ν_U since June 1955 are shown in Fig. 1. In addition to month-to-month variations which are of an accidental nature, there is seen to be a systematic trend. The length of the day was a minimum about September 1955 (speed of rotation at maximum) and has been increasing at a practically constant rate since then (speed of rotation decreasing).

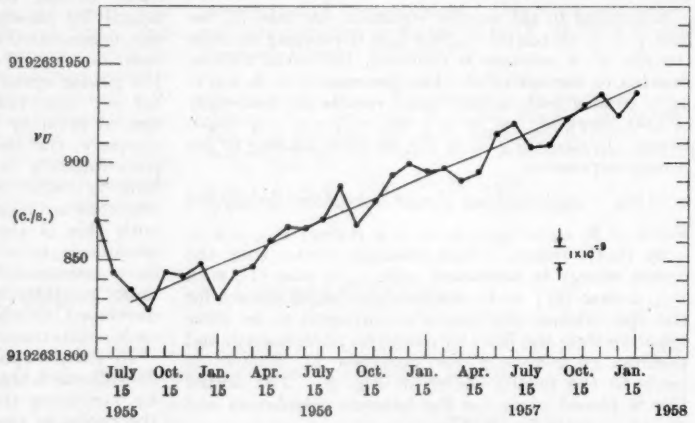

Fig. 1. Frequency of the cæsium resonance in terms of UT2

ν_U can be well represented since September 1955 by a straight line. This means that the seasonal variation for the past two years as determined with the aid of the cæsium standard is practically the same as determined with the aid of quartz-crystal clocks for several years previous to 1955.

Fig. 1 represents the non-periodic portion of the variation in the speed of rotation of the Earth. Since September 1955, this has been a constant deceleration of 5 parts in 10^9 per year, equivalent to an increase in the period of rotation of 0·43 msec. a year. This deceleration is about fifty times as large as that attributed to tidal friction. It is probable that it represents the irregular variation, but further observations are needed to confirm this.

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Effect of the Earth's Equatorial Bulge on the Life-time of Artificial Satellites and its use in determining Atmospheric Scale-Heights

PREVIOUS correspondents[1-3] have discussed the derivation of a simple formula for the life-time T of an Earth satellite. The formula concerned is:

$$T = \frac{3}{4}Pe\left(1+\frac{7}{6}e+\frac{1}{2}kae\right)\Big/\left(-\frac{dP}{dt}\right) \qquad (1)$$

where P is the period, dP/dt the rate of change of period with time, e the eccentricity, a the semi-major axis and $1/k$ the atmospheric scale-height. This formula is valid provided e is both sufficiently small and sufficiently large, and the last two terms on the right-hand side (given here for the first time) indicate the limitations on e.

From various sets of available orbit data, I find that the descent dates predicted by (1) vary with the epoch of the data, more recent data leading to earlier descent dates. For the Sputnik 1 sphere ($1957\alpha_2$), data of October 15 give January 30 ($\pm$ 4), whereas data of November 9 give January 18 ($\pm$ 2). The actual descent date was about January 2. For Sputnik 2 (1957β), data of November 9 give June 24 ($\pm$ 10), whereas data of February 4 give April 30 ($\pm$ 1). Although these dates refer strictly to the time when the orbit becomes nearly circular, they should be only a few days short of the descent dates.

This shortening of the life-time is attributed to the fact that the perigee points of both satellites have been rotating slowly towards the equator and hence, on account of the equatorial bulge, into denser air. The perigee of sphere $1957\alpha_2$ moved from 42° N. to 5° N. during its life-time; whereas for 1957β, the perigee was initially at about 53° N., and will reach the equator by March 19. An equatorial radius is in excess of a radius at latitude 45° by 11 km., and so the bulge is equivalent to an air-density change of about 60 per cent in the 200-km. altitude region. Formula 1 should therefore not be applied without considering the latitude variation of perigee. The neglect of this effect in Scott's[2] estimates happened to compensate for the omission of the last two terms in (1), so leading to surprisingly good predictions.

My attention was first directed to the effect of the equatorial bulge on perigee air-density ρ by the values in Table 1, which were derived from the formula:

$$\rho = \frac{1}{3\varkappa}\frac{(1-e^2)^{1/2}}{(1+e)^2}\left(\frac{2ke}{\pi a}\right)^{1/3}\left(-\frac{dP}{dt}\right) \qquad (2)$$

where $\varkappa = SC_D/m$, S being the effective cross-sectional area and m the mass of the satellite, and C_D the drag coefficient. (This formula is valid so long at e is not too small; and, in all cases considered, the contributions from higher-order forms and the effect of the Earth's oblateness amount to only of the order of a per cent.)

Perigee air-density values cannot be guaranteed to better than about 30 per cent on account of uncertainties in k and $\varkappa$. Density ratios relating to the same satellite object are, however, independent of k and $\varkappa$ and should be accurate to a few per cent. Thus the perigee air-density for 1957β increased between November 9 and February 3 by a factor of $1{\cdot}51(\pm 0{\cdot}06)$. The change in perigee distance between

Table 1. VALUES OF AIR DENSITY IN THE REGION OF 200-KM. ALTITUDE

Object	Sphere, $1957\alpha_2$*	Sphere, $1957\alpha_2$*	$1957\alpha_1$†	Rocket, 1957β‡	1957β‡
Epoch of data	October 15	November 9 (approx.)		February 3	
Perigee latitude	37° N.	26° N.	26° N.	49° N.	19° N
Perigee height (km.)	206 ($\pm$7)	201 ($\pm$4)	202 ($\pm$4)	211 ($\pm$4)	197 ($\pm$1)
Perigee air density (gm./c.c.)§	$5{\cdot}4\times10^{-13}$	$6{\cdot}7\times10^{-13}$	$7{\cdot}3\times10^{-13}$	$4{\cdot}6\times10^{-13}$	$7{\cdot}0\times10^{-13}$

* C_D taken equal to 2.
† $\varkappa$ taken equal to 1·8 times that of sphere $1957\alpha_2$ (as derived from the ratio of their initial rates of change of period with time).
‡ $\varkappa$ taken equal to 5–6 times that of rocket $1957\alpha_1$ on account of its greater mass.
§ Scale-height $1/k$ taken to be 25 km. Equation 2 shows that ρ varies inversely as the square root of the scale-height.

two epochs can be shown to correspond to a change of density of approximately

$$\rho/\rho_0 = (ae_0/a_0e)^{1/2} \qquad (3)$$

and this amounts to only 1·17 ($\pm$ 0·01) for 1957β between November 9 and February 3. The discrepancy between these two factors, amounting to 1·29 ($\pm$ 0·05), can be satisfactorily accounted for by the increase of 9·8 km. in the Earth's radius between 49° N. and 19° N. The value obtained for the atmospheric scale-height is then 39 ($\pm$ 6) km. The data for perigee-height for 1957β in Table 1 enables the scale-height to be determined as 34 ($\pm$ 11) km.

For sphere $1957\alpha_2$ the height data above are not sufficiently accurate for the scale-height to be found; but use can be made of the fact that 3·7 km. of the change arises from the equatorial bulge. Of the observed increase in air density by a factor 1·24 ($\pm$ 0·05), a factor 1·08 ($\pm$ 0·02) of this arises from the decrease in perigee distance as calculated from equation 3, so leaving a factor of 1·15 ($\pm$ 0·06) attributable to the 3·7-km. change in height. This leads to a value of 26 ($\pm$ 9) km. for the scale-height.

More accurate orbital data, particularly on the rate of change of period, are needed to take full advantage of the above method. It may then be possible to study the variations of scale-height with latitude.

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Application of the Kurie Plot to the Standardization of Pure Beta-Emitters

THE standardization of pure β-emitting nuclides becomes increasingly difficult as the energy of the radiation decreases, because of absorption and scattering effects which occur at the low-energy end of the β-spectrum. It may be possible to circumvent these effects by a technique employed by Waggoner, Moon and Roberts in connexion with a magnetic β-ray spectrometer[1]. This method consists of extrapolating to zero the straight Kurie plot which should be obtained for a single allowed β-ray transition. It is the purpose of this communication to show the relation between the slope of the Kurie plot and the absolute disintegration-rate of a radioactive source,

and to describe the proposed method of application to 4π-counting.

The notation adopted is that used by M. E. Rose[2]. For the sake of clarity, simplified equations are used which refer to allowed β-spectra only. The β-spectrum can be represented by a simplified form of the well-known Fermi equation:

$$N(W)\mathrm{d}W = K^2(W_0 - W)^2 pWF(Z,W)\mathrm{d}W \quad (1)$$

where $N(W)\mathrm{d}W$ is the probability per unit time that an atom will emit a β-particle in the energy range W to $W + \mathrm{d}W$; p is the momentum of the β-particle and W is its total energy; W_0 is the energy released in the nuclear transition; $F(Z, W)$ is the Coulomb field factor (Z referring to the daughter nucleus) and K^2 is a constant independent of W. The Coulomb field factor is also known as the Fermi function, and has been well tabulated for a range of Z and W values[2,3]. A measurement of the spectrum $N(W)\mathrm{d}W$ is made by means of a β-ray spectrometer the transmission factor of which is T. T is defined as the fraction of the particles emitted in a given energy-range detected by the spectrometer counter. If the number of atoms in the source is n, then the number of particles detected per unit time by the counter in the energy interval W to $W + \mathrm{d}W$ is

$$N_\beta(W)\mathrm{d}W = nTN(W)\mathrm{d}W \quad (2)$$

where $N_\beta(W)\mathrm{d}W$ has been corrected for background and dead-time.

Equations 1 and 2 can be rearranged to give

$$\left(\frac{N_\beta(W)}{pWF(Z,W)}\right)^{1/2} = (nTK^2)^{1/2}(W_0 - W) \quad (3)$$

which is the equation used for obtaining the Kurie plot. The left-hand side of (3) is plotted against W, as shown in Fig. 1. The graph is linear until the low-energy region is reached, and then deviates from a straight line because in this region the transmission T varies with the energy W. The variation is caused by the absorption and scattering of the low-energy β-particles. Over that portion of the Kurie plot which is linear, T is constant, and the square of the slope gives nTK^2, that is:

$$\tan^2\theta = nTK^2 \quad (4)$$

By definition

$$\lambda = \int_1^{W_0} N(W)\mathrm{d}W \quad (5)$$

where λ, the decay constant, is the probability of decay per unit time, and from (1):

$$\int_1^{W_0} N(W)\mathrm{d}W = K^2 \mathrm{f}(Z,W_0) \quad (6)$$

where

$$\mathrm{f}(Z,W_0) = \int_1^{W_0} (W_0 - W)^2 pWF(Z,W)\mathrm{d}W \quad (7)$$

Also, the law of radioactive decay can be expressed in magnitude as:

$$N_0 = \lambda n \quad (8)$$

where N_0 is the number of atoms disintegrating in unit time.

Therefore, by rearranging (5), (6) and (8):

$$N_0 = nK^2 \mathrm{f}(Z,W_0) \quad (9)$$

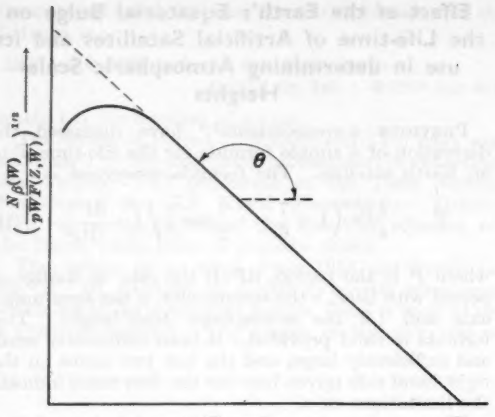

Fig. 1. Kurie plot of a pure β-emitter, according to equation (3); $\tan^2\theta = nTK^2$

and combining (4) and (9)

$$N_0 = \frac{\mathrm{f}(Z,W_0)}{T} \cdot \tan^2\theta \quad (10)$$

Numerical values of $\mathrm{f}(Z,W_0)$ have been extensively tabulated[4]. If T is also known, then the absolute disintegration-rate of a radioactive source can be derived directly from the slope of the Kurie plot by using (10).

A β-spectrometer for this work need not possess high resolution, but it is necessary that its transmission be accurately known, and that its response either be linear or also accurately known. It would seem that 4π-counters are ideally suited in this first respect, because their transmission factor over the linear portion of the Kurie plot is unity. It is also possible to construct gas proportional counters the response of which is linear, by taking care to keep the gas gain constant[5]. Thirdly, it is necessary, over the energy-range which is of interest, that the β-particle shall expend its entire energy in the sensitive volume of the counter. This can be arranged by operating the counter at a suitable high pressure[6]. The design of a suitable high-pressure proportional counter is therefore being investigated and the accuracy of this method, compared with integral $4\pi\beta$ counting, is being assessed.

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Photoelectric Response of Selenium-type Photovoltaic Cells to X-Rays

A COMMERCIALLY available selenium-type photovoltaic cell was irradiated with X-rays produced with a commercial type of low-voltage X-ray tube with a thermionic cathode and an inclined copper target. Lead covers with circular apertures of different diameters were placed over the photocell to alter the flux of X-rays on the surface of the cell at a constant X-radiation intensity, and the X-radiation intensity was varied by changing the anode current of the X-ray tube. Fig. 1 shows a family of curves representing the photocell current, I_p, as a function of the X-ray tube anode current, I_a, with the anode voltage, V_a, as parameter, the curves having been obtained with a distance of 25 mm. between the photosensitive surface of the cell and the centre of the target of the X-ray tube, 17·5 mm. of the distance being in the vacuum space of the tube, 1·5 mm. the thickness of its cylindrical envelope of soda-lime glass, and the remainder of the air space between the tube and the photocell surface. The curves marked *A* refer to an aperture of 240 mm.² in the lead cover, and those marked *B* refer to a 60-mm.² aperture.

The characteristics of Fig. 1 indicate a linear relation between photoelectric response and X-radiation flux irrespective of whether the flux is changed by altering the X-radiation intensity or by varying the size of the area of irradiation.

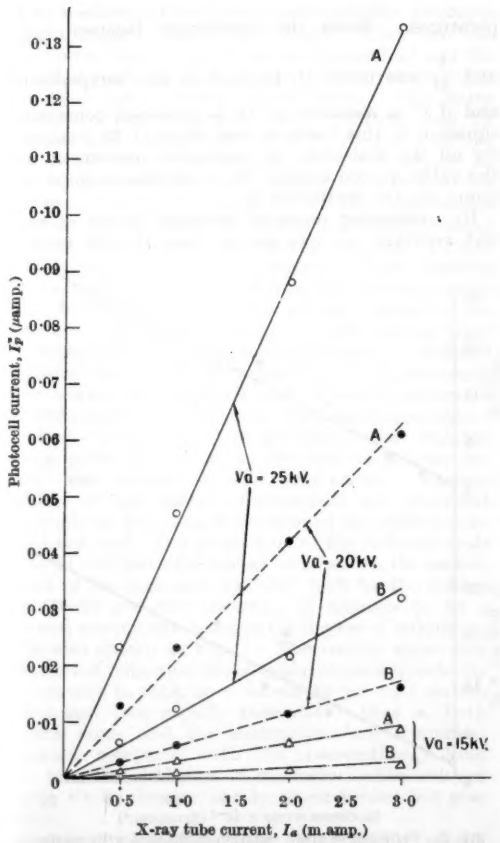

Fig. 1. Curves *A*, irradiation area, 240 mm.²; curves *B*, irradiation area, 60 mm.²

Increasing the aperture of the lead cover over the photocell to a diameter of 25 mm., compared with 17·5 mm. for obtaining the curves *A* in Fig. 1, demonstrated the reduction of radiation intensity towards the boundary of the X-ray beam. The photocurrent response indicated that the X-radiation flux increased only by 50 per cent, whereas it would have doubled if the X-radiation intensity had been uniform over the whole area of the aperture.

A second photocell of the same type gave a similar photoelectric response characteristic, but all photocurrent values were reduced to one-third of those of Fig. 1, although the two cells had the same photoelectric sensitivity to light. The fact that both cells were equally sensitive to light but differently sensitive to X-rays may probably be interpreted in terms of light being effective only at the surface of the photosensitive layer and X-rays being effective in its depth, and that there was a difference in the thickness and/or the structure of the photosensitive layers of the two cells. The depth effect of X-rays may possibly in part also account for the dependence of the photoelectric response on the anode voltage of the X-ray tube.

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Plasticity of Graphite

THE creep behaviour of graphite in the temperature range 1,300–2,000° C. has been examined for the first time. The experiments were carried out by applying loads to cantilevers heated *in vacuo* by the passage of an electric current and to spring specimens heated in a high-temperature high-vacuum furnace. The specimens were made in the laboratory by extruding a wide range of raw materials (pitch coke, petroleum coke, lamp black, cellulose and natural graphite). Springs of rectangular section were also machined from commercially manufactured materials (reactor graphite and commercial electrode graphite). The apparatus and techniques used in these experiments were similar to those used in dynamic experiments previously described[1].

It was found that, for a wide range of temperatures, raw materials, specimen geometries, flexural and torsional stresses, the creep deformation could be statistically fitted within the limits of experimental error to the function:

$$D_t = A + k \log_{10} t + Bt \qquad (1)$$

where D_t is strain at time t and t is time (min.).

A, k and B are constants for each experiment. Similarly, the creep recovery on removing the load conformed to the function:

$$D_t^1 = A^1 + k^1 \log t \qquad (2)$$

A typical creep curve is shown as a linearized plot in Fig. 1*a*. Fig. 1*b* is a plot of the deviations of the experimental points from the function determined by the method of least squares.

The coefficients k and B were linearly dependent on the applied stress at constant temperature and were related to the absolute temperature as follows:

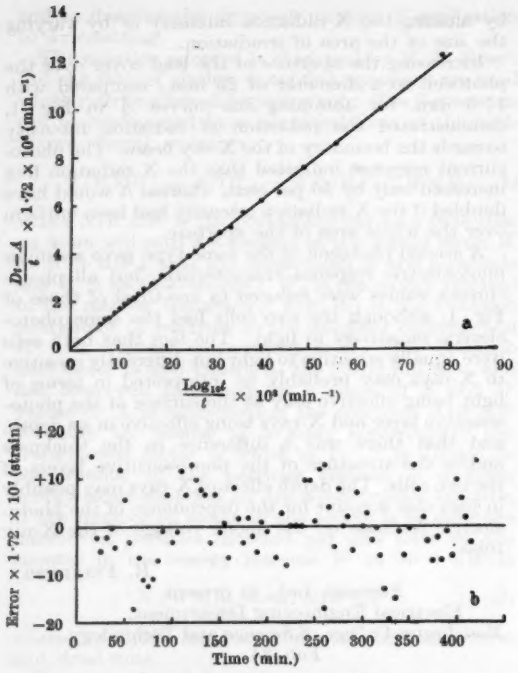

Fig. 1. (*a*) Linearized plot of typical creep curve; equation, derived by method of least squares: $D_t = 0{\cdot}87 \times 10^{-3} + 7{\cdot}0 \times 10^{-9}\, t + 8{\cdot}9 \times 10^{-4} \log_{10} t$. Graphitized cellulose carbon spring No. C12, temperature 1,560° C., maximum stress 8·9 $\times$ 10^{7} dynes/cm.^{2}. (*b*) Deviation of experimental points from the function derived by the method of least squares

$$k = K(\text{stress}) \exp\left(-\frac{\Delta E}{RT}\right) \qquad (3)$$

and

$$B = K^{1}(\text{stress}) \exp\left(-\frac{\Delta E^{1}}{RT}\right) \qquad (4)$$

where K and K^{1}, and ΔE and ΔE^{1} are constants, R the gas constant and T the absolute temperature. The stress relationship is demonstrated in Fig. 2.

The linearity of the stress–strain relationship made possible the use of specimens in which the applied stress was not uniform throughout, and strengthens the belief that equation 1 relates to the structure of the graphites examined and not to the particular stress systems applied to the specimens.

The available evidence shows that $K = C/M$ in equation 3, where M is the elastic modulus at room temperature appropriate to the stress system applied and C a constant for all the materials studied. This is illustrated in Table 1. The product $\frac{k}{\text{stress}} \times M$ is a constant at each temperature.

It is therefore reasonable to rewrite equation 3 as follows:

$$k = \frac{C}{M}(\text{stress}) \exp\left(-\frac{\Delta E}{RT}\right) (C \simeq 13) \qquad (5)$$

Since modulus and stress should depend on the same function of the density, this treatment eliminates the effect of density from equation 5. The constant ΔE in equation 5 was found to have a value of 21 kcal./mole for petroleum coke and cellulose carbon

Table 1. Correlation of Transient Creep Coefficients, Stress and Elastic Modulus for a Range of Materials.

(*a*) Spring specimens at 1,560° C.

Material	Modulus of rigidity at room temperature G_0 dynes/cm.$^{2} \times 10^{-10}$	$\frac{k}{\text{stress}}$ (dynes/cm.^{2})$^{-1} \times 10^{12}$	$\frac{k}{\text{stress}} \times G_0 \times 10^{2}$
Commercial electrode graphite	1·33	5·41	7·2
Reactor graphite	1·53	3·69	5·6
Petroleum coke	3·0	1·92	5·8
Reactor graphite	3·23	1·79	5·8
Cellulose carbon	10·0	0·77	7·7
			Mean = 6·4

(*b*) Cantilever specimens at 1,900° C.

Material	Young's modulus at room temperature E_0 dynes/cm.$^{2} \times 10^{-10}$	$\frac{k}{\text{stress}}$ (dynes/cm.^{2})$^{-1} \times 10^{12}$	$\frac{k}{\text{stress}} \times E_0 \times 10^{2}$
Pitch coke	7·0	0·96	6·7
Petroleum coke (uncalcined)	9·0	1·52	13·7
Petroleum coke (calcined)	10·0	1·38	13·8
Lamp black	13·0	0·97	12·6
Cellulose carbon	14·0	0·87	12·2
Natural graphite	22·0	0·60	13·2
			Mean = 12·0

springs, which were studied over a range of temperatures. Since the correlation between $\frac{k}{\text{stress}}$ and $\frac{1}{M}$ was found to be true at two temperatures, and if C is assumed to be a universal constant in equation 5, this leads to one value of 20 kcal./mole for all the materials, in reasonable agreement with the value quoted above. No such relationships were found for the coefficient B.

By examining repeated identical cycles of creep and recovery, it was shown that the Bt term in

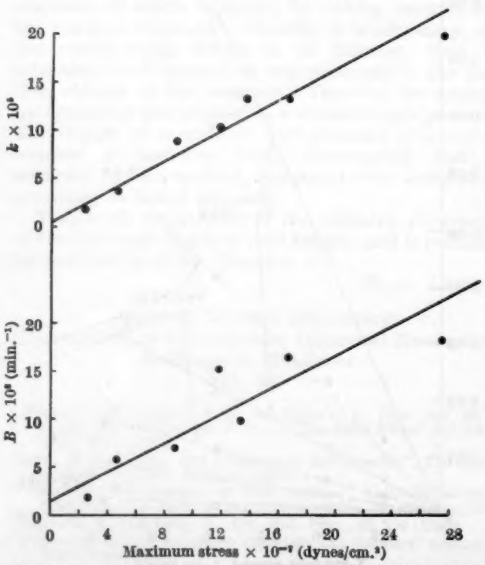

Fig. 2. Variation of creep equation coefficients with maximum applied stress for graphitized cellulose carbon spring specimens. Temperature, 1,560° C.

equation 1 contributed to a permanent set which could be removed only at graphitizing temperatures.

The effect of the gross grain structure on the plastic behaviour of graphite is not noticeable, since it appears possible to relate the transient term to the elastic modulus which, it has already been demonstrated[1], depends on the crystallite parameters of the 'grist' material. The steady-state term has not yet been found to be correlated with any of the known parameters of the materials.

This work forms part of a study of the plastic behaviour of graphite carried out under contract to the Atomic Energy Research Establishment, Harwell.

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Ease of Reduction of a Series of Coals and its Relation to their Structure

We wish to report an interesting variation in the ease of reduction of coals and solvent extracts of coals with change in ash-free carbon content (change in rank).

Two methods of reduction, each initially involving electron transfer, have been used. They are the reduction of coal with lithium in ethylamine[1] and the controlled potential electrolysis of dimethylformamide extracts of coal in dimethylformamide. The latter was carried out in a cell similar to that used by Bergman and James[2] at −2·2 V. (*versus* mercury pool) with 0·1 *N* tetraethylammonium iodide as supporting electrolyte: the electrolysis was followed by acetylation of the products *in situ* with acetic anhydride to prevent oxidation of hydroquinones produced from quinones present in the coal. Proton addition from the solvent normally follows electron addition from the lithium or from the mercury cathode[3]. In known aromatics a greater degree of reduction is effected by lithium in ethylamine than by electrolysis (for example, naphthalene is reduced to octalin[1] and to dihydronaphthalene[4] respectively).

The elementary analyses and infra-red spectra of the products showed that reduction had taken place; the electricity consumed in the electrolyses and the polarographic behaviour, in the case of solvent extracts, also supported this conclusion. Various measures of the degree of reduction are presented graphically in Fig. 1 as a function of the carbon content of the coal. The proportion of the reduced coals soluble in cold pyridine varied widely with the carbon content of the coal, and was very high for the coking coals (86–90 per cent carbon); it appears to be a valid and convenient index of the degree of reduction, and is also shown in Fig. 1. The results show that the extent of reduction of the coals increases markedly with increase in rank up to about 89 per cent carbon content and falls rapidly thereafter; that is, both low-rank coals and the anthracite show a marked reluctance, compared with the intermediate coking coals, to suffer addition of hydrogen. The solvent extracts show changes in the same sense, but less marked.

A further point arises from polarography of the products of electrolysis: although polarograms of the

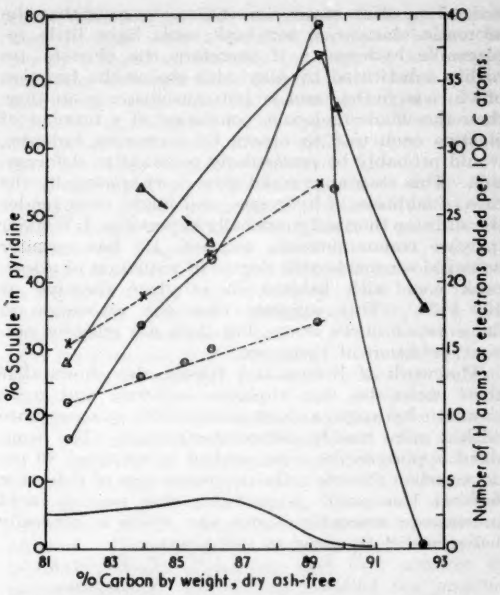

Fig. 1. Reduction of coals and coal extracts. ——, Coals: △, number of hydrogen atoms added per 100 carbon atoms (from elementary analysis); ⊙, per cent reduced coal soluble in pyridine (cold); —, per cent original coal soluble in pyridine (cold). – – – –, Coal extracts: ×, number of electrons added per 100 carbon atoms (from current consumption); ⊙, number of hydrogen atoms added per 100 carbon atoms (from elementary analysis). In calculating these figures the product reduced and acetylated at −2·2 V. has been compared with that reduced and acetylated at −1·0 V. where only quinone groups are reduced (ref. 12)

electrolysed solutions showed complete absence of waves, those of the products isolated from these solutions showed partial reappearance of the waves associated, in previous work[5], with aromatic reduction. This effect was most noticeable with the products from the low-rank coal extracts. The re-emergence of waves in the polarograms of the isolated products indicates a failure of the ions to complete the reduction by adding protons. This reluctance of the hydrocarbon ions to add protons evidently decreases with increase in rank of the coal.

The only explanation we are able to suggest at present for these changes in behaviour with rank concerns the deformation from planarity which in general occurs when hydrogen is added to aromatic systems, or more specifically, on proton addition to a hydrocarbon ion. Presumably this deformation of structure can only occur to a limited extent with low-rank coals, which indicates that the aromatic systems are held in a rigid cross-linked structure. The greater ease of deformation in the coals of higher rank would therefore indicate less rigidity and consequently less cross-linking of the aromatic systems. This idea has already been suggested by Given[6] in connexion with the poor reduction of a low-rank coal with lithium in ethylamine. Some confirmation for the idea can be deduced from the work of J. K. Brown[7], who, from an estimate of the aliphatic/aromatic hydrogen ratio determined spectroscopically in a series of coals, concluded that in low-rank coals the greater part of the hydrogen is present in methylene groups with little appearing on aromatic rings and still less as —CH_3 (Brown, J. K., private communication, and ref. 8). This, together with Hirsch's[9]

estimation of aromatic cluster size, suggests that the aromatic clusters in low-rank coals have little replaceable hydrogen; if therefore the clusters are highly substituted by alkyl side-chains the function of which is, in the main, to join one cluster to another, then the whole molecule, consisting of a number of clusters each tied to others by numerous linkages, would probably be particularly resistant to deformation. This resistance could slow down materially the rate of addition of hydrogen, and might even render the addition thermodynamically impossible. I. Wender (private communication, and ref. 10) has recently achieved a considerable degree of reduction of a low-rank coal with lithium in ethylene diamine at 100–117°. This suggests that the resistance to deformation slows down, but does not entirely prevent, addition of hydrogen.

The work of Brown and Hirsch also shows that there must be less aliphatic material and more aromatic hydrogen as rank is increased, in accordance with a more readily deformed structure. The argument applies to the coals studied up to about 89 per cent carbon content; the decreased ease of reduction beyond this point is probably due to the rapid increase in aromatic cluster size which is generally believed[7,9,11] to occur at this point.

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Electrocapillary Action of Corrosion Inhibitors

Indelli and Pancaldi[1] and I[2] have compared some characteristic phenomena occurring at the interface of a dropping mercury microelectrode and electrolyte solutions with phenomena encountered in corrosion inhibition[3]. It was found[2] that the effectiveness of numerous corrosion inhibitors is reflected in their ability to suppress various polarographic maxima (abnormal current peaks in the current-voltage curves of the mercury microelectrode). In particular, it was shown that the order of relative inhibiting effectiveness of a number of amine inhibitors (for the iron – sulphuric acid system) is the same as that of their effectiveness in suppressing certain polarographic maxima. These amines (both aliphatic and aromatic) were most effective in suppressing maxima corresponding to the negative branch of the electrocapillary curve at which mercury is negatively charged with respect to the solution. This is consistent with Mann's[3] conclusion that amines inhibit the corrosion of iron in sulphuric acid by becoming adsorbed on the cathodic areas of this metal. It was thus demonstrated that significant similarities exist between the processes involved in polarographic maxima and their suppression, on one hand, and in metallic corrosion and its inhibition, on the other[4]. Campbell[5] has also employed polarographic techniques in detecting corrosion inhibitors.

Based on similar reasoning, De[6] has recently proposed "A Unified Theory of the Mechanism of Inhibition of Corrosion of Iron in Acid and Neutral Media based on the Electrocapillary Behavior of Ions". This theory provides a basic approach to many aspects of corrosion inhibition processes. A few years ago, I obtained some experimental results on the electrocapillary properties of representative corrosion inhibitors; these results are quite pertinent to the above theory. Mercury was employed, since electrocapillary studies with solid metals present serious experimental difficulties.

The electrocapillary curves of mercury were obtained in 1 *N* sulphuric acid, 1 *N* hydrochloric acid and 0·1 potassium chloride by applying a potential across a dropping mercury electrode and a mercury pool. The dropping time, which is proportional to the surface tension of mercury, was employed in plotting the electrocapillary curves. The results obtained with aliphatic amines are shown in Fig. 1. It is seen that the inhibiting behaviour of these amines as discussed by Mann[3] is reflected in their electrocapillary properties; that is, their overall effect on the electrocapillary curve of mercury, their specific effect on the negative branch of the curve, and the shift of the electrocapillary maximum towards less negative values, increase with increasing molecular weight of the amines. This behaviour, of course, indicates that in acid solutions amines are adsorbed in the form of ammonium ions, RNH_3^+. The lower members of the aliphatic amines, namely, methyl- and ethyl-amine, in the concentration range considered, affected the electrocapillary curve only to a small extent.

Representative inorganic inhibitors were also tested for their effect on the electrocapillary curve of

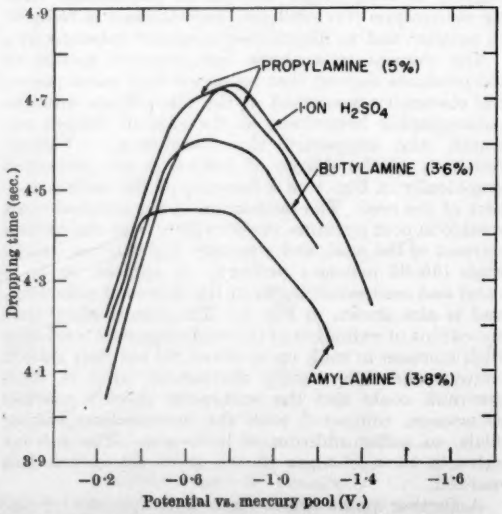

Fig. 1. Effect of aliphatic amines on the electrocapillary curve of mercury in sulphuric acid

mercury in 0·1 *N* sodium chloride and 0·1 *N* potassium chloride solutions. The following inhibitors were included at a concentration of 0·03 per cent: sodium tetraborate, sodium benzoate, trisodium orthophosphate, potassium dichromate, sodium nitrite and sodium silicate. All these inhibitors affected the positive (less negative) branch of the electrocapillary curve, indicating the adsorption of the anions of these inhibitors on the positively charged mercury surface. Such behaviour in this type of inhibitors is among the requirements of De's theory regarding solid metals.

In electrocapillary phenomena, particularly from the point of view of corrosion inhibition, competitive adsorption must be of importance. In aqueous solutions a number of ions are usually present which can compete for sites on a metal surface. Phenomena associated with such competitive processes should, therefore, be taken into consideration in an electrocapillary approach to corrosion inhibition. With this in mind, an attempt was made to determine the action of a given inhibitor on the electrocapillary curve which was obtained in the presence of another inhibitor. Among the above inorganic inhibitors studied, it was found that the effect of potassium dichromate on the electrocapillary curve was independent of any other inhibitor present. Alternatively, in a solution containing potassium dichromate, addition of one or more of the rest of the inhibitors had no further effect on the electrocapillary curve. This result can be considered as representing a case of competitive adsorption where dichromate ions are the most strongly adsorbing among the ions considered. They can thus displace the other ions from the mercury surface; the reverse process does not take place at the concentrations employed. Competitive adsorption in corrosion inhibition could probably be studied indirectly—by dissolution rates and/or electrode potential measurements—much more conveniently than by the electrocapillary action of inhibitors on solid metals.

These results on mercury cannot, of course, serve as a direct verification of the electrocapillary action of corrosion inhibitors; but they will encourage electrocapillary studies on solid metals.

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Influence of Metallic Ions on the Reaction of Ethylene Diamine with Epinephrine and Norepinephrine

THE reaction of ethylene diamine with epinephrine (and norepinephrine) leads to the formation of a highly fluorescent material which is used for the estimation of catechol amines in biological fluids according to a procedure first described by Weil-Malherbe and Bone[1] and slightly modified by a number of other workers.

We found that the presence of metallic ions, even in traces, greatly influences the intensity of fluorescence obtained by this reaction. Among the salts that possess such a marked catalytic action are chiefly aluminium chloride (or acetate) and copper sulphate, although Erne and Canbäck[2] have utilized ammonium molybdate for the same purpose. Ferric chloride, on the other hand, appears to decrease the fluorescence of epinephrine while copper sulphate decreases that of norepinephrine.

In the light of these findings, it is more than probable that the presence of aluminium salts in the eluate should be responsible, at least in part, for the increase of fluorescence observed when ethylene diamine is allowed to react with epinephrine dissolved in aqueous acetic acid solutions that have passed through an alumina column, as compared with solutions in pure acetic acid[3,4]. 10 ml. of acetic acid solution that had been passed through a column of 0·7 gm. of alumina prepared according to Weil-Malherbe and Bone were found to contain about 10 μgm. Al^{+++}. The increase of fluorescence under such conditions was about 30 per cent. The addition of 10 μgm. Al^{+++} (in the form of acetate or chloride) to pure acetic acid increased the fluorescence by 17 per cent. The difference, however, could be explained by the presence of other impurities in alumina. Spectrographic analysis of one sample of purified product (Brickman and Co., suitable for chromatographic adsorption) revealed the presence of minute amounts of copper, iron, gallium and silicium. The influence of these elements on this reaction is under investigation.

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A Suggested Revision of Nomenclature—Angiotensin

THE vasoactive peptide resulting from the action of renin on an alpha-globulin was discovered by two groups of investigators with the result that it received two trivial names, angiotonin and hypertensin. Synthesis of the octapeptide has now confirmed the identity of this peptide and justifies dropping the double nomenclature. We propose the simplified name, angiotensin, and its derivatives angiotensinase and angiotensinogen. Angiotensin is a hybrid word but does, we think, have the advantage of being easy to pronounce even with a variety of accents, is euphonious, and is understandable despite the most recalcitrant microphone.

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Allelomorphism and the Chemical Differences of the Human Hæmoglobins A, S and C

In previous communications on this subject, one of us[1,2] reported that normal human hæmoglobin (*A*) and sickle-cell hæmoglobin (*S*) differ in only one out of nearly 300 amino-acids in the half-molecule, and that this is the only demonstrable difference in primary chemical structure. We now wish to report on a similar investigation into the structure of another abnormal human hæmoglobin—that of hæmoglobin *C* disease.

The protein was obtained from individuals known to be homozygous for the hæmoglobin *C* gene. It was first denatured by heat and then digested with trypsin, and the resulting mixture of peptides was analysed by the two-dimensional combination of paper electrophoresis and paper chromatography called 'fingerprinting'[1,2]. The trypsin-resistant 'core' of hæmoglobin *C* was treated with hydrochloric acid–acetone to remove the hæm group. It was then made completely soluble by digestion with chymotrypsin, resulting in a second mixture of peptides. Further examination followed, both by fingerprinting and by more detailed paper chromatography and electrophoresis of groups of peptides from those parts of the fingerprints where the resolution had not been good enough.

When fingerprints of both the chymotryptic and tryptic digests were compared with those of hæmoglobins *A* or *S*, all the peptides of the normal protein were found in their correct positions with the exception of one, which had disappeared. Its place was taken by two peptides in new positions (Fig. 1). The missing peptide is No. 4, the same one which carries the difference between hæmoglobins *A* and *S*. Therefore it is clear that the identical portion of the hæmoglobin *A* molecule is involved in the change to hæmoglobin *C*. Moreover this appears to be the only change, since all the other peptides in the tryptic fingerprint had amino-acid compositions indistinguishable from those of their hæmoglobin *A*, or *S*, counterparts. The peptides of the 'core' still remain to be analysed.

The two new hæmoglobin *C* peptides, called 4*a* and 4*b*, were isolated from tryptic digests by eluting appropriate peptide bands obtained by paper electrophoresis[3], at *p*H 6·4 at 20 V./cm.; this was followed by a second purification using cooled paper electrophoresis at *p*H 3·6[3] and 35 V./cm. The amino-acid composition and the N-terminal amino-acid of each peptide were determined qualitatively using the methods previously described[2]. The sequence of

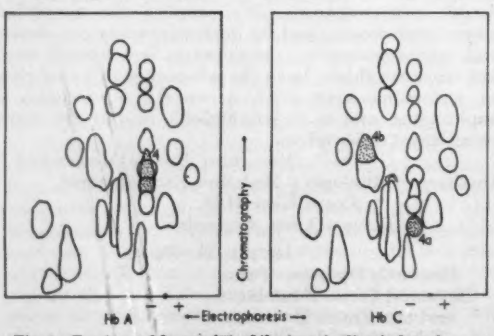

Fig. 1. Tracings of fingerprint of the trypsin digests from hæmoglobin *A* and *C*

Table 1. Structure of the Hæmoglobin *A* and *S* No. 4 Peptides and the Hæmoglobin *C* Nos. 4*a* and 4*b* Peptides

(His = histidyl-, Val = valyl-, Leu = leucyl-, Thr = threonyl-, Pro = prolyl-, Glu = glutamyl-, Lys = lysine).

Hæmoglobin *A* . . . His–Val–Leu–Leu–Thr–Pro–*Glu*–Glu–Lys . . .

Hæmoglobin *S* . . . His—Val—Leu—Leu—Thr—Pro—*Val*—Glu—Lys . . .

Hæmoglobin *C* . . . His–Val–Leu–Leu–Thr–Pro–*Lys* Glu–Lys . . .

amino-acids was found by partial acid hydrolysis and end-group analysis[4] of the products.

The amino-acid sequences of the No. 4*a* and 4*b* peptides from hæmoglobin *C* are given in the last line of Table 1. Together they add up to the sequence of amino-acids found in the normal No. 4 peptide with the exception of the first glutamic acid residue, which is replaced by lysine. The splitting of the No. 4 peptide into two components during trypsin digestion is now explained, since the new lysine residue constitutes an additional trypsin-sensitive bond. On the basis of these findings we conclude that hæmoglobin *C* differs from hæmoglobin *A* and *S* by only a single amino-acid residue out of nearly 300 in the half-molecule. Moreover, the same glutamic acid residue of hæmoglobin *A* which was changed to valine in hæmoglobin *S* is now replaced by lysine in hæmoglobin *C*. This change from an acidic to a basic amino-acid, involving the loss of two net negative charges per half-molecule, is in agreement with the observed electrophoretic behaviour of hæmoglobin *C*[5].

These results have interesting genetic implications. They are the first steps in a search for a correlation between the linear fine structure of a gene such as that determined recently by Benzer[7] and Pontecorvo[8], and the linear structure of the polypeptide chain of the protein the synthesis of which that gene controls.

The gene mutations which cause the production of the abnormal hæmoglobins *S* and *C* are inherited in a Mendelian manner through nuclear genes[9–11]. Hæmoglobin *C* provides a second example, after hæmoglobin *S*, of the effect exerted by a mutation of this kind on the protein which the gene produces. In both cases the effect is small, since only one out of nearly 300 amino-acids has been altered. We would assume that there have been small alterations in corresponding places on the gene. Hæmoglobin *C* and *S* are most probably independent examples of the same phenomenon, since there is no reason for believing that the two mutations did not arise independently. The fact that both abnormalities occur with high frequency and alter the same amino-acid might well be an accident of natural selection and not an indication of a high mutation-rate at this one particular locus.

Our results also shed light on the position of these two mutations on the hæmoglobin gene or genes. Genetic evidence[9–11] shows that the hæmoglobin *S* and *C* mutations are allelic or occur at linked sites; but the statistical evidence is not sufficiently strong to distinguish between these two possibilities. If we assume a direct relationship between the internal (linear) structure of the gene, and the linear arrangement of the amino-acid residues in the hæmoglobin molecule, then the finding that the same amino-acid residue, glutamic acid, is altered in both mutations implies that they are indeed allelic

mutations and occupy the same site on the gene. Thus if these ideas are correct the chemical investigation of proteins such as the human hæmoglobins can provide a powerful, though indirect, tool to help the geneticist in mapping the positions on the gene where certain mutations occur.

In order to obtain sufficient statistical data and a sufficient number of mutants, such a programme must eventually turn to proteins from micro-organisms. However, it is hoped that the abnormal human hæmoglobins will provide a few more useful examples of the effects of gene mutations on protein structure.

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Protection against Death due to Ozone Poisoning

In a research programme on the physiological effects of ozone, an attempt was made to determine the mechanism of ozone poisoning by studying chemical protection before exposure. Swiss albino mice were treated by intraperitoneal injections of the test chemical followed by exposure for 3 hr. to a concentration of 8–25 p.p.m. of ozone. This ozone concentration caused death in 10–80 per cent of the animals[1]. Usually 10 control (no prior treatment) animals and 10 treated animals were exposed together in a large glass chamber 12·5 in. × 30 in. × 16 in. to ozone generated by a water-cooled corona discharge type of ozonizer. The results of these experiments are recorded in Table 1.

Since death due to ozone poisoning is accompanied by considerable œdematous fluid in the respiratory system[2], atropine sulphate was tested as a possible protective agent, for it is widely used in surgery to minimize bronchial and nasal secretion. It was successful in preventing death in some of the mice exposed to ozone. Whether this protection is due to the blockage of the response of effector cells to stimulation of postganglionic cholinergic fibres is unknown. The role of the nervous system in pulmonary œdema is not clear. However, Balagot, Reyes and Sadove[3] believe that the autonomic nervous system is implicated. Sarnoff and Sarnoff[4] report that blockade of the sympathetic impulses to systemic vessels lowers pulmonary blood volume and pressure. Avaido and Schmidt[5] present evidence of chemoreceptors in the lungs, with a possible implication in œdema.

The success of the atropine sulphate, a cholinergic blocking drug, in affording some protection against ozone poisoning may be explained by reduction of œdema via the nervous system. However, hexamethonium chloride (Table 1), a ganglionic blocking drug, did not protect mice from death induced by ozone. The ganglion-blocking agents prevent the initiation of postganglionic impulses at the ganglia, while atropine prevents the action of postganglionic impulses upon smooth muscles or glands.

Several reducing substances were tested to determine whether they would protect mice against death from ozone. Since ozone is a powerful oxidizing agent, there is a good possibility that damage to the respiratory system is due to the formation of free radicals and peroxides. Thus a reducing agent should aid animals to survive an exposure to ozone, provided that an intraperitoneally injected reducing substance would be carried as a reducing agent in the blood stream to the respiratory system. Cole *et al.*[6] found that sodium nitrite injected intraperitoneally afforded some protection against death due to radiation.

Table 1. Effects of Various Agents Injected into Mice in Protection against Death from 8–25 p.p.m. of Ozone for 3 hr.

Agent	Dosage/mouse (mgm.)	Dosage/mouse (ml.)	Treated mice: Total	Treated mice: Survived (*a*)	Treated mice: Dead (*b*)	Control mice: Total	Control mice: Survived (*a*)	Control mice: Dead (*b*)	X^{2*}
Atropine sulphate	0·00325	0·1	118	88	30	119	74	45	4·2
Hexamethonium chloride ('Hexameton', Burroughs Welcome)	0·125	0·1	110	70	40	111	63	48	0·59
Sodium thiosulphate (*p*H 7·7, sodium hydroxide)	40	0·5	71	55	16	70	42	28	4·62
Ascorbic acid (sodium ascorbate, Barry Laboratories)	20	0·2	90	70	20	90	56	34	5·18
Glutathione (*p*H 8·0, sodium hydroxide)	65·8	1·0	20	12	8	20	11	9	0·0
Sodium nitrite (*p*H 7·2, sodium hydroxide)	2·5	0·5	20	7	14	20	18	2	0·0
Sodium nitrite (*p*H 7·2, sodium hydroxide)	1·75	0·25	67	35	32	68	35	33	0·0
p-Aminopropiophenone (in 2 parts 100 per cent ethyl alcohol and 8 parts propylene glycol)	1·0	0·1	40	11	29	40	22	18	0·0

* G. S. Snedecor, "Statistical Methods", p. 19 (Iowa State College Press, Ames, Iowa, 1940).

* $X^2 = \dfrac{(ad - bc)^2 (a + b + c + d)}{(a + c)(b + d)(a + b)(c + d)}$

If the value of X^2 is 3·84, there is more than a 95 per cent chance that the treated population is different from the control.

With this in mind, other reducing agents were used. Both sodium thiosulphate and ascorbic acid (Table 1) protected mice against death by ozone poisoning. These compounds may react with ozone before it has a chance to come into contact with lung tissue, or afford protection by decreasing capillary permeability in the lungs, and by sustaining the alveolar capillary cells during conditions of anoxia. Sodium nitrite at 2·5 mgm. per mouse (Table 1) did not protect mice but made ozone more toxic. At a level of 1·75 mgm. per mouse there was no effect on mortality due to ozone. The apparent increase in death-rate of mice injected with 2·5 mgm. of sodium nitrite can be explained by the induction of methæmoglobinæmia[7] by this compound. A sharp reduction in available hæmoglobin would handicap an animal severely injured by ozone and would hasten death due to asphyxiation.

Glutathione and *p*-aminopropiophenone[9], which have had some success in protection against death due to radiation, were not successful in protecting against death induced by ozone poisoning. Gerschmann and colleagues[10] pointed out the similarities between oxygen poisoning and injury due to radiation and found that glutathione protected against oxygen poisoning. It appears that compounds which protect against death by radiation and oxygen poisoning are not effective against ozone poisoning. The difference in protection is due to the fact that damage in ozone poisoning appears to be limited to the respiratory tract only, whereas in radiation and oxygen poisoning the whole body is involved.

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Isolation of β-Sitosterol-D-Glucoside from Groundnut Phospholipids

Naturally occurring sterol glycosides (sterolins) were first characterized in 1913 by Power and Salway[1], since which time these compounds have been isolated from a variety of plant materials[2,3].

In the course of experiments on the lipids of groundnuts, a sterol glycoside has been isolated from a crude phospholipid fraction and has been identified as β-sitosterol-D-glucoside.

The initial phospholipid was produced on an industrial scale; in order to remove small amounts of triglyceride the material was washed several times with three times its weight of acetone, dissolved in ether and reprecipitated with acetone. The precipitate was filtered off on a Buchner funnel and final traces of solvent then removed *in vacuo*.

129 gm. of this material was ground with about 300 gm. of anhydrous sodium sulphate and the mixture extracted with acetone in a large Soxhlet extractor for 22 hr. The acetone extract on cooling gave a yellow waxy solid which after washing with ether yielded a white powder, insoluble in most of the usual solvents but soluble in pyridine. Further quantities of this material were obtained by concentrating the acetone extract, and in all 2·3 gm. (1·8 per cent of the crude phospholipid) was obtained.

The product was recrystallized from pyridine–ethanol as a loose white solid giving positive Liebermann–Burchard and Molisch tests, m.p. 290–292° (dec.) and $[\alpha]_D^{20}$ − 45·7. These values correspond with those reported by other workers[4,5] for β-sitosterol-D-glucoside, and the identity of the solid was confirmed by the melting points and specific rotations of the acetyl and benzoyl derivatives, and by identification of the sterol and sugar components following hydrolysis of the glycoside by the method of Thornton and co-workers[6]. Chromatographic analysis showed glucose to be the only carbohydrate component in the water-soluble portion of the hydrolysis products, and the presence of glucose was confirmed by osazone formation. Recrystallization of the ether-soluble hydrolysis products yielded a sterol, m.p. 135–136°, $[\alpha]_D^{20}$ − 37·17, in 75 per cent yield. The acetate (m.p. 126° $[\alpha]_D^{20}$ − 43·01) and benzoate (m.p. 142–143°, $[\alpha]_D^{20}$ − 15·1) correspond to β-sitosterol derivatives.

In further experiments the crude phospholipid was fractionated with alcohol; the alcohol-insoluble material corresponded to 75 per cent of the initial phospholipid and contained 87·5 per cent of the total sterol glycoside.

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Site of Catabolism of Serum Albumin

The relative importance of the liver, kidneys and intestines for the catabolism of serum albumin has been examined in Swiss albino mice, 5–6 weeks of age. Mouse serum albumin and human serum albumin were labelled with iodine-131 as described elsewhere[1] and given to the mice intravenously, about 0·5 μc. or 5–15 μgm. iodoalbumin per mouse. The biological half-lives of the radioiodinated albumins were determined by one or more of three methods: (1) the living whole mouse was counted at intervals in a crystal scintillator; (2) pooled serum was obtained by exsanguination of two or three mice at a time

Table 1. Half-lives of Iodinated Albumins in Mice

Conditions (see text)	Half-lives during first 24 hr.* (days)
Normal diet: unoperated or sham-operated	0·7
Partial hepatectomy (40 per cent)	1·7
'Thorotrast' (0·6 ml.)	2·2
Indian ink (0·1 ml.)	1·8
Starvation	1·1
Sham operation and starvation	1·2
Bilateral ureteral obstruction	1·4–1·7
Bilateral nephrectomy	1·4
Intestinal resection	0·7

* Average values for at least 15 animals per group, excepting nephrectomy, which included eight animals. Data on individual animals varied by less than 20 per cent from the average.

from a given group and the protein-bound radioactivity of the serum determined; (3) protein-bound radioactivity in the individual whole mouse of a given group was estimated after homogenization of the animal in 10 per cent trichloracetic acid. All animals were given sodium iodide in their drinking water throughout the period of an experiment. Surgical operations were performed under ether anæsthesia. In these experiments, iodinated human albumin behaved *in vivo* as did iodinated mouse albumin; detectable antibodies to human serum albumin were not formed during the periods of study chosen.

The half-life of serum albumin in normal mice was found to be about 0·7 day (Table 1) (this value has been averaged with additional data obtained by G. Terres and W. Wolins and is based on more than 50 animals). Since the mice in several experiments were anorexic, the half-life of albumin in mice not given food was determined and found to be about 1·1 days. Sham operations were also performed in which the peritoneal cavity was opened and the intestines lifted out and replaced. The half-life of albumin in sham-operated mice with or without food was similar to that obtained for unoperated mice on the same diet (Table 1).

The ureters were obstructed bilaterally in a group of mice approximately 3 hr. prior to injecting labelled albumin by applying a gold clamp at the base of the bladder. These animals were not given food. The half-life of serum albumin under these conditions was found to vary from 1·4 to 1·7 days in different groups of mice; these values should be compared with 1·2 days for the sham-operated controls. The half-life of albumin in mice that were bilaterally nephrectomized was 1·4 days.

Removal of both large and small intestines appeared to accelerate the catabolism of iodinated albumin, since the half-life was only 0·7 days as compared with 1·2 days for starved controls (Table 1).

Removal of 40 per cent of the liver resulted in a marked decrease in the catabolism of albumin (Table 1). During the first day after the operation, the half-life was found to be 1·7 days. During the second day, the half-life of albumin was 0·9 days. Five days after the operation, the half-life of albumin was normal and post-mortem examination revealed that the liver had regenerated to normal size. The hepatectomized mice were eating soon after the operation, and the half-life value found is to be compared with that for mice on a normal diet. Removal of approximately 40 per cent of the liver decreased the fractional rate of catabolism by about 50 per cent. Similarly, removal of about 20 per cent of the liver decreased the fractional rate of catabolism about 20 per cent.

An attempt was made to determine the relative influence of the hepatic cells and the Kupffer cells on albumin catabolism. 'Thorotrast', which is a 24–26 per cent suspension of thorium dioxide, and indian ink are known to block the reticulo-endothelial system. Consequently, 0·05–0·1 ml. of indian ink or 0·2–0·6 ml. of 'Thorotrast' was given to mice intravenously, followed 1 hr. later by iodinated albumin; there was a profound inhibition of albumin catabolism (Table 1). Large doses of 'Thorotrast' reduced the catabolism of iodinated albumin to an extent even greater than that observed in mice with 40 per cent of their livers removed.

It would appear from these results that the liver and kidneys in mice play significant parts in the catabolism of albumin. The liver would seem to have the greater importance, since removal of only 40 per cent of the liver was more effective than complete nephrectomy. At the cellular level, the experiments with indian ink and 'Thorotrast' strongly implicate the reticulo-endothelial system of the liver in this catabolism, although a possible role of the hepatic cells cannot be excluded.

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Effects of Pituitary Hormones and Cortisone upon Liver Regeneration in the Hypophysectomized Rat

The finding that growth hormone increased the rate of mitosis and nucleic acid synthesis in rat regenerating liver[1], suggested that this hormone might play an important part in liver regeneration following partial hepatectomy. To test this hypothesis it was necessary to study the effect of hormones upon liver regeneration after removal of the pituitary.

Three series of experiments were performed on rats subjected to partial hepatectomy 7–28 days after hypophysectomy. It is believed that the use of this preparation has not been previously described; full details will be reported later (by J. T. H.). Rats were killed at two hourly intervals from 27 hr. to 50 hr. after partial hepatectomy and mitotic counts were made on the livers.

The first series of saline-injected controls (80 rats) 14–21 days after hypophysectomy showed that liver regeneration can occur in the absence of the pituitary, but is delayed. Normal rats show a peak of regeneration of about 40 mitoses/1,000 cells at about 28½ hr. after partial hepatectomy[2]; but in hypophysectomized rats the peak is at 38–45 hr. and is only 20–30 mitoses/1,000 cells.

A second series of 80 hypophysectomized rats were given hormone replacement at hepatectomy and during liver regeneration. Six groups were used, given respectively: growth hormone only, crude pituitary extract only, cortisone only, growth hormone +

cortisone, crude pituitary extract + cortisone, and a control group injected with saline. Giving growth hormone + cortisone or crude pituitary extract + cortisone resulted in an increase of the height of the mitotic peak with little alteration of the time at which maximum regeneration occurred. Results from growth hormone and crude pituitary extract alone were equivocal.

In the group treated with cortisone only, a consistent and characteristic cytoplasmic and nuclear degeneration was noted (by D. B. C., who did mitotic counts on these two first series of rats). The cells undergoing degeneration appeared to follow a series of changes, beginning with a hyaline droplet type of degeneration of the cytoplasm, followed by vacuolation of the nucleus and extrusion of the nucleolus. The nucleus in the more degenerate cells became pyknotic and finally broke into fragments. These changes were much more marked than the cytoplasmic vacuolation and nuclear displacement reported in liver cells of mice treated with cortisone[2].

A third series of experiments was then begun (by J. T. H.) to test the hypothesis suggested by the work of Bullough (recently reviewed[4]), that the nutritional state of the liver at hepatectomy greatly influenced the subsequent regeneration, and that some conditioning of the cell by hormone activity was essential for normal regeneration.

Injections of the same combinations of hormones were therefore given three days prior to hepatectomy and during the period of regeneration.

65 hypophysectomized rats have so far been examined, and in all those receiving cortisone only (2 mgm./100 gm. rat twice daily) no mitoses were found at any regeneration time from 27 to 60 hr. (Cortisone inhibition of liver regeneration in the mouse, with intact pituitary, has been reported[3].) Glycogen content of the liver was high at hepatectomy and was still high at post-mortem, suggesting that glycogen utilization was small in the cortisone-treated rat. Except in very small doses, growth hormone or crude pituitary extract given alone was toxic to hypophysectomized – partially hepatectomized rats, many animals dying through hypoglycæmia and ketosis. Such material as was available indicated that mitotic rates were low (5–20 mitoses/1,000), and that glycogen accumulation was also low. Further work is in progress.

When growth hormone or crude pituitary extract was given with cortisone the whole picture changed; the highly pyknotic and degenerating nucleus gave place to more normal appearances with clear mitotic figures. When the dose of growth hormone was in the correct proportion to the dose of cortisone high mitotic counts were seen. High accumulation and utilization of glycogen also occurred. Thus, 1·5 mgm. growth hormone or 0·6 ml. crude pituitary extract (100 gm. rat twice daily) with 2 mgm. cortisone gave high counts of 45–60 mitoses/1,000 cells. Reducing the dosage of either to an eighth and keeping the cortisone dose at 2 mgm. gave low mitotic counts and slight signs of cytoplasmic and nuclear degeneration.

Thus growth hormone prevented the inhibition of mitosis and the nuclear degeneration produced by cortisone. With cortisone alone there was nuclear degeneration in spite of accumulation of glycogen in the cytoplasm. Failure to regenerate deoxyribonucleic acid has also been reported after cortisone administration to the intact mouse[5]. These facts suggest the possibility of a metabolic block set up by cortisone between the cytoplasm and the nucleus; this block is removed or neutralized by growth hormone. Conversely, this work supports that of many workers showing growth hormone to diminish glucose uptake by the cell in hypophysectomized animals, and in particular is direct support for the view that growth hormone requires the co-operation of adrenal corticoids for normal carbohydrate metabolism[5].

In physiological conditions it may well be that growth hormone is the more constant basal secretion allowing nuclear activity and this is modified by hour-to-hour variation in adrenal corticoid output. When cortisone is excluded there are indications that glycogen utilization is related to mitotic rate. It is possible that the autonomy of neoplastic cells is in part a loss of response to corticoid inhibition, and the relation between these two possibilities is being examined. In those cases of inoperable cancer which have been treated by hypophysectomy and maintained on cortisone, these studies suggest that part of the beneficial therapeutic response may be due to a direct effect of cortisone on the dividing cancer cells, probably accentuated by absence of pituitary growth hormone.

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Fine Structure of the Alveolar Wall of the Lung

Since electron microscope techniques have been applied to histology, several workers have confirmed that the blood–air barrier of the lung consists of a capillary endothelium, a basement membrane and an uninterrupted alveolar endothelium. The permeability of this three-layered wall is explained, in the classical physiological literature, solely by a passive physicochemical mechanism.

Palade[1] was the first to observe with the electron microscope that the fine structure of the capillary wall was much more intricate than had been previously assumed. He saw invaginations of the plasma membrane which are pinched off to form small vesicles of 500–750 A. diameter. It seems likely that they move across the endothelial cytoplasm and approach the opposite plasma membrane. Palade[2] himself believes that substances from the capillary lumen can thus be actively and selectively incorporated into the endothelial cytoplasm. This mechanism, formerly called pinocytosis, appeared to depend, so far as the capillary endothelium is concerned, upon the requirements of the surrounding medium.

Quite recently, Moore and Ruska[3] described capillary endothelia of the mammalian heart and

suggested that the plasma membrane vesiculation mechanism, described by Palade[1,2], is a prevalent process of active and selective transport of substances across the cytoplasm and cell membranes. They call this exchange mechanism 'cytopempsis'.

Nevertheless, Moore and Ruska[3] suppose that in pulmonary capillaries physicochemical permeability is enough to maintain transport through the blood–air barrier, because their layers are extremely thin. Therefore, they did not expect to find morphological images of cytopempsis at this level.

We did not consider the negative results convincing proof of the absence of cytopempsis, therefore we have re-investigated the fine structure of this three-layered wall.

The present observations are based upon techniques recently described[4] and were made on lungs of adult albino mice.

Structural details assumed to be concerned in cytopempsis are shown in the alveolar wall in Figs. 1 and 2. There are many small vesicles of 500–700 A. diameter in the endothelial cytoplasm. They are usually spherical, consisting of a relatively light portion surrounded by a thin dark membrane. The exterior and the interior plasma membrane invaginations show in several places. Some of the spherules approach these invaginations and often fuse with the bottom of them.

The thin epithelial lining of the alveolar cells surrounding the capillary vessels has a structure remarkably like that of the endothelial cytoplasm. There are also small vesicles of about the same size as those described in the endothelium. Invaginations of exterior and interior plasma membranes can easily be identified.

Finally, numerous small cell-membrane infoldings, similar to those belonging to the exterior cell membranes, are found in contact with the alveolar basement membrane. Some of these in profile are closed, whereas others appear to be partially or completely open at the level of the basement membrane.

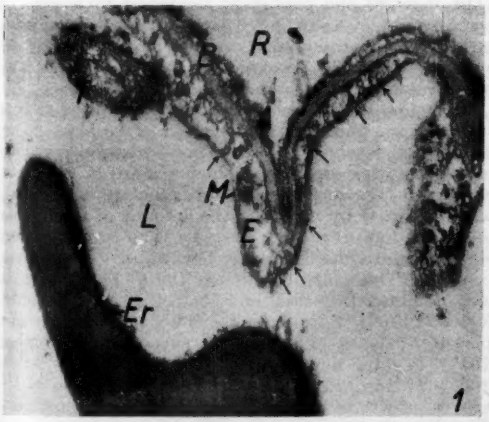

Fig. 1. Blood–air barrier in mouse lung. A large capillary lumen (*L*) is visible below, with a red blood cell (*Er*) and a thrombocyte (*T*) in close contact with the endothelial lining. Vesicles, which are bounded by dense membranes, appear throughout the entire endothelial cytoplasm (*E*), often in connexion with small invaginations (→) of the exterior plasma membrane. A mitochondrial profile (*M*) can be recognized in the endothelial cytoplasm. The alveolar lumen (*R*) is bounded by the alveolar epithelium (*A*). The basement membrane (*B*) is represented by a layer between endothelium (*E*) and epithelium (*A*). (× 25,000)

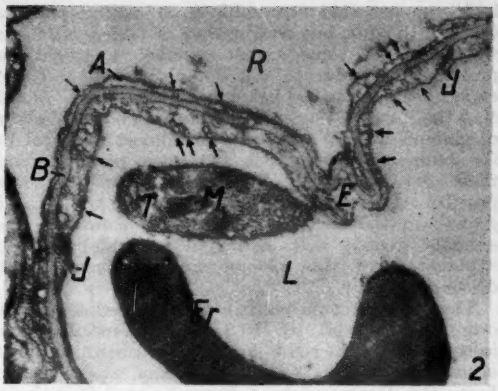

Fig. 2. Another portion of the blood–air barrier in mouse lung, showing numerous small vesicles in the capillary endothelial (*E*) and the alveolar epithelial (*A*) cytoplasm, and invaginations (→) of the exterior and interior plasma membranes. The vesicles are often associated with the bottom of an infolding of the cell membrane. Two endothelial junctions (*J*) are visible. (× 26,000)

Schulz[5] described vesicles of 500–1000 A. diameter within the alveolar and endothelial cytoplasm of the blood–air barrier in lungs of mammals submitted to artificial lung-œdema. He is convinced that these structural details must be due to the experimental œdema produced. Obviously, he did not know that Palade[3] had found the same vesicles three years before in quite normal circumstances, within the capillary endothelium of the mammalian heart. Moreover, Schulz did not use controls, an omission which makes his conclusion less convincing. The electron microscope literature is still too small to distinguish between the so-called 'normal fine structures' and artefacts.

On the basis of these results, we believe that the idea that transmission of substances through the alveolar wall occurs only by passive diffusion should be further studied. The occurrence of cytopempsis within the normal alveolar wall is important evidence in favour of both alveolar epithelial and capillary endothelial cells being active and selective in the exchange of substances in the lung.

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Inability of Hydrogen Peroxide to influence the Survival-Time of Rats bearing *RD3* Sarcoma and the Walker Carcinoma

It has recently been claimed that orally administered hydrogen peroxide (0·45 per cent by weight) causes regression of the transplantable Walker carcinoma in rats[1], and it was also claimed that two of four cancerous patients benefited from this treatment. It seemed to us that orally administered

hydrogen peroxide was unlikely to survive passage through the gut, but an impurity or added stabilizer which was to some extent carcinolytic might be present. In order to try out this likelihood the experiments described below were made. We found that the survival-times for rats bearing either Walker carcinoma or *RD*3 sarcoma were almost identical in the animals treated with hydrogen peroxide and those fed tap-water. There was, however, some possible difference affecting the rate of tumour growth in the two groups (possibly slower in the animals treated with hydrogen peroxide) and an explanation of that phenomenon is given in the discussion below.

The *RD*3 sarcoma used in these experiments was originally induced by 1 : 2 : 5 : 6-dibenzanthracene injection into the right flank of an inbred strain of albino rats. The Walker carcinoma was obtained from the Department of Experimental Pathology, University of Leeds.

Animals used in these experiments were inoculated subcutaneously in the right flank with 0·2 ml. of a thick pasty suspension of tumour mince under strict aseptic conditions. (Walker carcinoma or *RD*3 sarcoma.)

The diet used throughout these experiments was diet 86 purchased from the North-Eastern Agricultural Co-operative Society Ltd., Bannermill Place, Aberdeen. All animals were fed *ad lib.* and were housed in separating cages and weighed individually twice a week.

The commercial concentrated aqueous solution of hydrogen peroxide (Laporte Chemicals Ltd., Luton) was diluted to give a final concentration of 0·45 per cent (by wt. : the suggested optimum of Holman[1]). This solution was fed *ad lib.* to the experimental groups of animals. The solution was replaced every 3 days and an analysis of the hydrogen peroxide concentration showed that no deterioration had occurred.

Experiment 1. Male rats were inoculated with *RD*3 sarcoma in the right flank. At the end of 5 days, 66 animals showing fairly uniform palpable tumour nodules measuring approximately 1·0 cm. in diameter were selected and divided into two groups. Group *A* received 0·45 per cent hydrogen peroxide from then on until the end of the experiment while the control group *B* received ordinary tap-water. Table 1 summarizes the results obtained. There was no statistically significant difference between the survival times and the final tumour weights in these groups.

Table 1. The Effect of 0·45 per cent Hydrogen Peroxide (as a Substitute for Drinking Water) on the Growth of Transplanted *RD*3 Sarcoma, Host Tissues, and on Survival-time in the Rat

Treatment started 5 days after transplantation of the tumour)

Exp. 1	Group *A* : Fed 0·45 per cent hydrogen peroxide		Group *B* : Fed tap-water	
	Rats with continued tumour growth	Complete regressions	Rats with continued tumour growth	Complete regressions
No. of rats	13	20	16	17
Survival-time (days)	37·6±34·3	136	34·6±25·0	136
Final tumour wt. (gm.)	65·5±61·5	none	92·3±45·5	none
Initial host wt. (gm.)	239·0±18·7	231·0±10·9	230·0±13·2	234·0±14·4
Final host wt. (gm.)	208·0±38·3	280·0±30·2	218·0±40·5	309·0±21·2

Table 2. Effect of 0·45 per cent Hydrogen Peroxide (as a Substitute for Drinking Water) on the Growth of Transplanted Walker Carcinoma, Host Tissues, and on Survival-time in the Rat.

(Treatment started 5 days after transplantation of the tumour)

	Exp. 2		Exp. 3.	
	Fed hydrogen peroxide	Fed tap-water	Fed hydrogen peroxide	Fed tap-water
No. of rats	14	15	18	17
Survival-time (days)	25·8± 8·5	26·7± 4·0	20·1± 3·4	21·9± 4·2
Final tumour wt. (gm.)	73·4±30·7	97·8±60·0	40·1±11·4	58·5±12·9
Initial host wt. (gm.)	279·0±26·,	278·0±31·2	240·0±11·6	240·0±12·8
Final host wt. (gm.)	232·0±43·5	300·0±20·0	173·0±39·2	248·0±35·9

Experiment 2. Male rats were inoculated with the Walker carcinoma. At the end of 5 days, 29 animals showing fairly uniform palpable tumour nodules measuring about 1·0 cm. diameter were selected and divided into two groups and treated in the same way as animals in exp. 1. Table 2 summarizes the results obtained. Once again there was no statistically significant difference between the survival times and the final tumour weights in these groups, although as in exp. 1 there was a lower final body-weight and tumour weight in the experimental animals.

Experiment 3. This is a repeat of exp. 2 ; but, as in this experiment the Walker carcinoma grew at a faster rate than that in exp. 2, the results were considered separately from those in exp. 2.

Once again hydrogen peroxide failed to prolong significantly the survival rate of the treated animals. The tumours in group *A* were, however, significantly smaller than those in group *B* : the final host weight of group *A* was less than that of group *B*, but not significantly so.

In view of the persistent tendency to a smaller body-weight in animals receiving hydrogen peroxide in all our experiments, it was decided to study the effect of hydrogen peroxide on the food intake and body weight of normal animals.

Experiment 4. Forty-eight rats were divided into two groups. Both groups were fed *ad lib.*, but group *A* (24 rats) received 0·45 per cent hydrogen peroxide instead of the tap-water which group *B* (24 rats) received. The amount of food eaten by each group was estimated by weighing the amount of food given and that left over and wasted. The animals were weighed individually every few days. The initial weight of the control rats was 189 ± 11 gm. (mean and standard deviation) and that of the experimental rats was 190 ± 9 gm. At the end of the experimental period (57 days) the rats in the control group weighed 253 ± 21 gm. and the experimental rats weighed 236 ± 13 gm., showing a significant difference in the rate of growth in the two groups. Group *A* consumed 23·8 kgm. food and group *B* 28·4 kgm.

The results of our experiments fail to confirm the findings of Holman[1]. In common with Green and Westrop[2] we find no evidence to suggest that hydrogen peroxide increases the survival-time of rats bearing the Walker carcinoma.

So far as the effect of hydrogen peroxide on final tumour size is concerned our results are more difficult

to interpret. In any experiment designed to reveal inhibition or stimulation of tumour growth the nutritional status of the animals must be taken into consideration (Tannenbaum[3]; Rous[4]; Ghadially and Wiseman[5]), for it is well known that if the animal loses weight tumour growth is likely to be impaired. The results of exp. 4 (above) on non-tumour rats show that hydrogen peroxide diminished food intake and retarded normal growth, and a tendency for animals receiving hydrogen peroxide to show a decrease in carcass weight and somewhat smaller tumours is to be expected.

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Spontaneous Crystallization of Amylase from Pancreatic Juice of the Rat

In the assay of secretin by Love's method[1] in which pancreatic secretion from the fasted rat is collected in calibrated capillary tubes, it was observed that a slight precipitate very occasionally formed in the tube at room temperature. When the secretion was kept at +2° C. a heavy white deposit almost invariably formed within two days or so which consisted of very fine birefringent needles, often in balls, fans, or sheaves (Fig. 1). The difference in ultra-violet absorption of the secretion before and after formation of the deposit (Fig. 2) suggested that the latter might be a protein. Further experiments showed it to be amylase, and it became of interest to compare its properties with those of crystalline pancreatic α-amylase from human[2] and pig[3].

Isolation and recrystallization. The crystals were only sparingly soluble in water and could be washed repeatedly in cold water. They were much more soluble above *p*H 10, and could be recrystallized by suspending in water, adding ammonia to a final concentration of 0·2 *M*, agitating for 15–20 min., and centrifuging; about one-quarter of an equivalent of hydrochloric acid was then added, the slight turbidity was spun down after half an hour, and the tube placed in a closed container with several ml. of dilute sulphuric acid to absorb ammonia, the whole

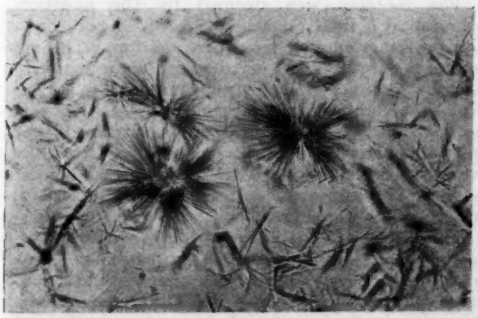

Fig. 1. Crystals separating spontaneously from rat pancreatic juice (polarized light. × 144)

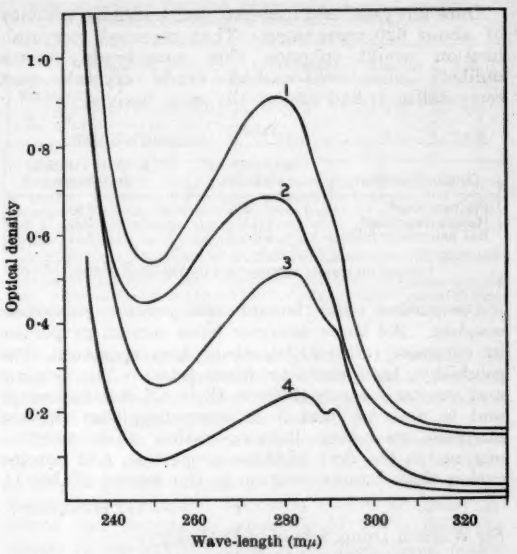

Fig. 2. Ultra-violet absorption (1 cm.) of: (1) pure pooled pancreatic secretion of three rats, collected over a period of 11–12 hr. (with frequent stimulation by secretin) diluted 1 in 40; (2) supernatant from the same after 7 days at 2° C., diluted 1 in 40; (3) recrystallized material, 0·256 mgm./ml., *p*H 7; (4) difference between 1 and 2

being kept at 2° C. Several days were required for crystallization, and the crystals thus obtained have not yet been larger than those separating spontaneously from crude pancreatic juice.

Stability. Well-washed crystals suspended in water appeared to retain their activity at 2° C. for many weeks. At 20° C. all activity was destroyed in a few seconds in 0·02 *N* hydrochloric acid; in acetate buffer *p*H 4, about nine-tenths of the original activity remained after 3 hr., and at *p*H 5 there was little or no destruction. In the *p*H range corresponding to 0·1–1·0 *M* ammonia the stability showed a sharp change. Thus, in 1·0 *M* ammonia at 20° C. destruction was virtually complete after 30 min.; in 0·5 and 0·1 *M* ammonia after 3 hr. about 30 per cent and 90 per cent of the original activity remained. A suspension of crystals dried quickly over phosphorus pentoxide and kept over it for two weeks retained only about one-quarter of its original activity.

Solubility. A dense suspension of crystals was distributed among a number of sealed glass capillaries which were gently agitated at the appropriate temperature for varying lengths of time. After centrifuging, the concentration of amylase in the supernatant was estimated in terms of its amylase activity. In water the approximate solubility was: at 2° C., 0·3 mgm./ml.; at 20° C., 1·5 mgm./ml.; at 37° C., 3 mgm./ml.

The crystals still formed spontaneously in the presence of bile or of 'Teepol' (which was sometimes used for ensuring smooth movement of the meniscus in the secretin assay).

Amylolytic activity. This was measured by the method described by Noelting and Bernfeld[4] based on that of Sumner and Howell[5], using British Drug Houses 'Analar' starch as substrate. The potency is expressed in units equivalent to the number of milligrams of maltose liberated by 1 ml. of enzyme solution in 3 min. at 20° C.

Once recrystallized material had a specific activity of about 620 units/mgm. That repeated recrystallization would enhance this considerably seems unlikely since well-washed crude crystals (not recrystallized) had almost the same activity.

Table 1

Origin of amylase	*p*H range of stability	Activity (maltose units/mgm.)
Pig pancreas*	7– 8·5	630
Human pancreas*	4–11	1,000
Rat pancreatic juice	5–10·5	620

* Based on results summarized by Bernfeld (ref. 6)

Comparison with human and porcine pancreatic amylase. All three enzymes have certain properties in common (ultra-violet absorption spectrum, low solubility, high stability when pure). The porcine and human enzymes differ in their *p*H stability-range and in activity, and it is interesting that the rat amylase resembles human, rather than porcine, enzyme in the first of these properties, and porcine rather than human enzyme in the second (Table 1).

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Serine–Glycine Interconversion in Plant Tissues

The conversion of serine to glycine in animal tissues was first demonstrated by Shemin[1] by a feeding experiment using serine labelled with nitrogen-15 and carbon-13 in the carboxyl group. The involvement of a folic acid derivative as a co-factor in the reaction was shown both by Kisliuk and Sakami[2] and Blakley[3].

That the interconversion occurred in plant tissues seemed probable in view of labelling data obtained by Tolbert and Cohan[4], who fed 1-^{14}C- or 2-^{14}C-labelled glycollate to wheat and barley leaves and found, in short experiments, that serine and glycine were the only major products labelled. The 2-C atom of glycollate was observed to enter the 3-C atom of serine, presumably glyoxylate formed by oxidation of the glycollate being split by the Sakami reaction to form formate[5], which is known to enter largely into the 3-C atom of serine[6]. Attempts to demonstrate the interconversion in cell-free systems from plants have not previously been successful[4].

This communication reports the occurrence of this interconversion in a cell-free system prepared from turnips. The tissue was homogenized in 2-3 vol. cold 0·2 *M* potassium phosphate buffer, *p*H 7·4, in a bottom-drive blender. The suspension was strained through a linen cloth and then centrifuged at 1,000*g*, for about 5 min. to remove cells and debris. Ammonium sulphate was then added to 80 per cent saturation. The protein was separated by centrifugation and dissolved in about 30 ml. of the same buffer. The solution was dialysed overnight against a flow of 2·5 l. of 0·01 *M* buffer, *p*H 7·4. The enzyme preparation was centrifuged at 30,000*g* for 10 min. before use. All these operations were carried out in a cold-room at 2° C.

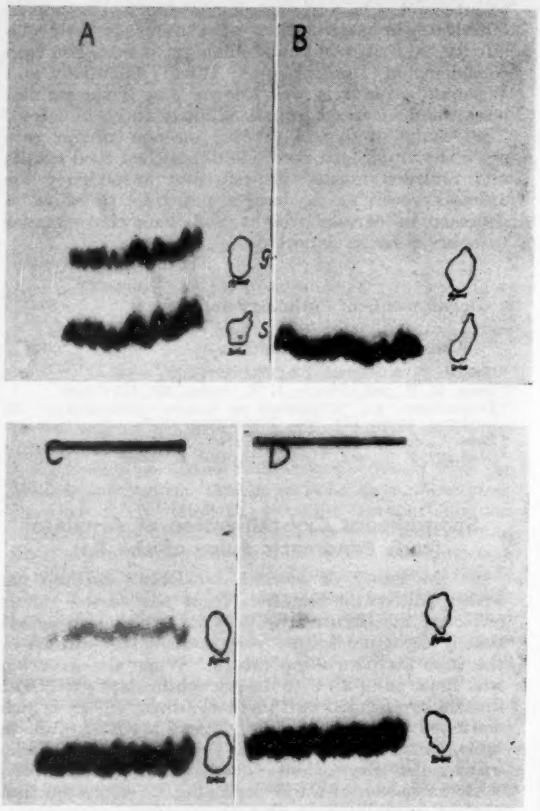

Fig. 1. Radioautographs of chromatograms demonstrating serine–glycine interconversion. *A*, Full system; *B*, ethanol at zero time; *C*, no pyridoxal phosphate; *D*, no tetrahydrofolic acid; *G*, glycine; *S*, serine markers. The full system contained: enzyme, 1 ml.; generally labelled carbon-14 L-serine 8×10^4 counts per min.; L-serine carrier to a final concentration of 1 μmole; glycine, 1 μmole; DL-tetrahydrofolic acid approximately 0·33 m*M*; pyridoxal phosphate, 0·25 m*M*; Mg^{2+}, 1 μmole. Total volume 1·53 ml. The flasks were gassed with hydrogen and incubated at 37° for 150 min.

The DL-tetrahydrofolic acid solution was prepared by the catalytic hydrogenation of folic acid in neutral aqueous solution[7].

The reaction was stopped by the addition of ethanol to a final concentration of 80 per cent and the protein removed by centrifugation. The supernatants were reduced to dryness on a water-bath, and the contents of the dishes transferred to Whatman No. 1 filter paper in 50 per cent ethanol. The solvent used to run the chromatograms contained acetone (80 parts), triethylamine (5 parts) diluted to 100 with water[8]. The papers were dried and exposed to X-ray paper. The appearance of the latter after development is shown in Fig. 1.

There appears to be an absolute requirement for tetrahydrofolic acid, presumably established by the prolonged dialysis alone; the enzyme had not been treated with 'Dowex-1-Cl'[2]. The reverse reaction has also been demonstrated, starting with glycine generally labelled with carbon-14. The enzyme

catalysing this reaction has also been shown to occur in extracts of immature cauliflower.

Further work is in progress on quantitative aspects of this reaction and similar C_1-transferring reactions are being studied.

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Carbon Dioxide Fixation in Particulate Preparations from Barley Roots

CARBOXYLATION of phosphoenolpyruvate in plant material has been reported by various workers[1–5]. In the present investigation we have observed it in particulate preparations from barley roots. This reaction, coupled with malic dehydrogenase activity in the presence of reduced diphosphopyridine nucleotide, leads to the incorporation of carbon-14 dioxide into malate and other organic acids.

The particles prepared from 6-day old barley roots were separated by centrifuging between 2,000 and 16,000 × *g*. Exposure to labelled potassium bicarbonate was carried out for a period of 1 hr. After acidification to terminate the reaction and removal of the excess carbon-14 dioxide, the medium was centrifuged to give two fractions: the supernatant and the residue. Aliquots of the supernatant and the residue were plated and from these the total carbon-14 dioxide fixation was determined.

Initial experiments in the absence of reduced diphosphopyridine nucleotide and with phosphoenolpyruvate showed a marked stimulation of the carbon dioxide fixation as compared to the fixation with pyruvate. Table 1 shows the fixation obtained in the two systems. Radioautographs of the paper chromatograms of the supernatants from both systems showed that only traces of labelled malate were present. 2,4-Diphenylhydrazones were prepared, and the activity expressed as the percentage of the total carbon-14 fixed gave figures of 80 per cent for the phosphoenolpyruvate and 5 per cent for the pyruvate. Radioautographs of paper chromatograms showed that in both systems labelled oxalacetate and pyruvate were formed, with a large accumulation of labelled oxalacetate in the presence of phosphoenolpyruvate. The results indicated that conditions were limiting for the further metabolism of the labelled oxalacetate.

The presence of added reduced diphosphopyridine nucleotide resulted not only in an increase in the total carbon dioxide fixation, but also in the activity of the ether-soluble fraction, particularly in malate. The organic acids in the supernatant were isolated by ether extraction followed by silica gel chromatography after the method of Bulen *et al.*[6]. Addition of malate increased the total fixation; however, the proportion of activity in the ether-soluble fraction remained the same except in the presence of added reduced diphosphopyridine nucleotide.

Table 1. CARBON-14 DIOXIDE FIXATION IN BARLEY ROOT PARTICLES WITH NO ADDED REDUCED DIPHOSPHOPYRIDINE NUCLEOTIDE
(Activity as percentage of total carbon-14 added)

Fractions	Supernatant	Residue	Total
Substrate			
1. Pyruvate (sodium salt)	1·1	1·0	2·1
2. Phosphoenolpyruvate (cyclohexamine salt)	12·0	2·6	14·6

Reaction mixture: 1 ml. particles containing 1·30 mgm. nitrogen, 60 μmoles substrate, 4·5 μmoles magnesium chloride, 0·6 μmoles manganese chloride, 90 μmoles phosphate buffer (1) *p*H 5·6, (2) *p*H 7·4 and 1 μmole potassium bicarbonate-^{14}C with $2·5 \times 10^5$ counts/sec. carbon-14 activity in a total volume of 3·3 ml.
In addition: (1) Adenosine triphosphate 9 μmoles; (2) adenosine monophosphate 9 μmoles.
Experimental conditions: Temperature, 25° C.; exposure period, 1 hr.; reaction terminated by 0·5 ml. 2 *N* sulphuric acid; excess carbon-14 dioxide removed by bubbling with inert carbon dioxide for 15 min.

The addition of reduced diphosphopyridine nucleotide to the medium stimulated the malic dehydrogenase activity, resulting in reduction of labelled oxalacetate to malate. Spectrophotometric determinations had shown the presence of malic dehydrogenase in the preparations. The presence of added malate apparently stimulated carbon dioxide fixation. The addition of malate in the presence of reduced diphosphopyridine nucleotide would result not only in this increase in fixation, but also serve as a trap for the malate formed by the reduction of the labelled oxalacetate. Results from experiments in which the added reduced diphosphopyridine nucleotide was increased twofold in the presence of malate showed a reduction in the total carbon dioxide fixation. The addition of oxalacetate (18 μmoles) to the medium markedly decreased the fixation.

The results show that this particulate preparation from barley roots provides an active system for carbon dioxide fixation through carboxylation of phosphoenolpyruvate. The results shown in Table 2 are representative of the general level of fixation, although in some experiments with added reduced diphosphopyridine nucleotide and malate as much as

Table 2. CARBON-14 DIOXIDE FIXATION IN BARLEY ROOT PARTICLES.
(Activity as percentage of total carbon-14 added)

Treatment	PEP	PEP + DPNH	PEP + DPNH + Malate	PEP + Malate
Total fixation	13·08	28·27	30·77	28·87
Total ether extract	0·86	6·04	12·99	1·64
Fraction				
Acetate	0	0·06	6·12	0·01
Pyruvate	0	0·03	0·03	0·01
Fumarate	0·06	0·88	2·16	0·14
Succinate	0·09	0·33	0·25	0·22
Pyrrolidone carboxylate	0·31	0·30	0·34	0·38
Oxalate	0·04	0·05	0·10	0·08
Malate	0·29	4·13	9·69	0·66
*iso*Citrate	0·03	0·18	0·25	0·10
Citrate	0·03	0·06	0·04	0·02
Tartrate	0·01	0·02	0·01	0·02
Fixation in ether extract expressed as percentage of total carbon-14 fixed	6·6	21·4	42·2	5·8

Reaction mixture: 1 ml. particles containing 1–2 mgm. nitrogen, 1 μmole phosphoenolpyruvate (PEP) cyclohexamine salt, 3 μmoles magnesium chloride, 1·2 μmoles manganese chloride, 9 μmoles adenosine monophosphate, 90 μmoles phosphate buffer at *p*H 7·4, and 1 μmole potassium bicarbonate-^{14}C with $2·5 \times 10^5$ counts/sec. carbon-14 activity in a total volume of 4·3 ml. 1·6 μmoles reduced diphosphopyridine nucleotide (DPNH) and 18 μmoles malate added as indicated.
Experimental conditions: see Table 1.

75 per cent fixation of the total carbon-14 added, and 53 per cent incorporation into the ether-soluble fraction, have been obtained.

A full account of the work will be presented elsewhere. We wish to thank Dr. L. Jacobson for his helpful suggestions throughout the investigation, and Dr. E. Conn for his generous supply of reduced diphosphopyridine nucleotide.

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Decumbin, a New Compound from a Species of *Penicillium*

An organism isolated during a microbiological study of corn spoiled in storage produced an aroma reminiscent of exaltone and crystalline bodies in artificial culture. The chief component of the crystalline bodies has been isolated as colourless, odourless needles, melting at 204° C. We have named this compound decumbin. We have concluded from work to be presented elsewhere that it is a previously unreported dihydroxy, α-β unsaturated lactone ($C_{16}H_{24}O_4$).

The organism producing decumbin has been identified as a strain of *Penicillium decumbens* Thom. (We thank Dr. Kenneth Raper for assistance in specific identification of the mould.) Our strain differed from the American Type Culture Collection No. 10436 (Raper N.R.R.L. 742) strain in that the A.T.C.C. strain did not produce detectable amounts of decumbin in comparable cultures. Both strains produce the characteristic aroma, however, and other characteristics convince us they are the same species.

Among several media tried, the production of visible crystals was best upon a broth prepared by steaming 200 gm. of peeled diced potatoes in 500 ml. of tap water for 30 min. The fluid was drained through one layer of cheese cloth, added to 20 gm. of commercial glucose, and made up to 1 litre. Stationary surface culture was used since the decumbin produced in submerged culture was more difficult to purify. Sterile potato dextrose broth, 300 ml. per rectangular, 2-quart milk bottle, was inoculated with a heavy spore suspension of *P. decumbens*. In about six days at 23–26° C., growth appeared complete with uniform grey-green sporulation and orange droplets of fluid on the surface of the mycelium. Needles of decumbin up to ¼ in. long attached to the submerged side of the mycelium began to appear after about eight days. Cultures were usually harvested after 10–12 days, but a small increase in decumbin yield continued for several more days.

To isolate decumbin, the contents of 100 bottles were strained through two layers of cheese cloth, and the mycelium extracted with three 1-litre portions of boiling methanol. The beer was chilled to 10° C., the precipitate collected, and extracted with 200–300 ml. of hot methanol. The combined methanol extracts were chilled overnight, filtered, diluted with 100 ml. of distilled water, and concentrated *in vacuo* until free of methanol. During the concentration, decumbin crystals began to form and, after chilling to 10° C., were filtered from the aqueous solution and the latter discarded. The average yield of this crude decumbin, m.p. about 190° C., was 278 mgm./l. of medium in a total of 1,404 bottles processed. Individual cultures yielded up to double this amount.

Decumbin was purified by washing the crude crystals with petroleum ether (3 ml./gm.) and recrystallizing them from 50 per cent (v/v) aqueous methanol (33 ml./gm.) and ethyl acetate (60 ml./gm.). The pure decumbin produced by several recrystallizations from these two solvents was not altered by careful sublimation *in vacuo* or drying *in vacuo* over phosphoric anhydride at 100° C.

The solubility of decumbin at 26° C., determined by weight loss from a single crystal after 19 hr. with frequent stirring, was 0·6 mgm./l. of water and 1·2 mgm./l. of 9·5 per cent ethanol. Absolute ethanol dissolved about 24·9 gm./l. These solubility characteristics made biological testing of decumbin difficult. For example, decumbin crystals were tasteless, but a saturated solution in 50 per cent ethanol applied to the back of the tongue was bitter.

Preliminary tests with decumbin showed it to be toxic to rats and to goldfish, and inhibitory to wheat germination, but not an active antibiotic under the tested conditions. Decumbin gave no zones of inhibition when 1 mgm./ml. solutions in 40 per cent (v/v) methanol in water were used in agar cup diffusion tests against *Staphylococcus aureus*, *Escherichia coli*, and *Hormodenrum cladosporoides*. A sample of *Triticum aestivum* var. Knox, of which 92 per cent germinated on filter paper moistened with water, was reduced to 82 per cent germination by 10 per cent (v/v) ethanol in water and to 52 per cent by 1·2 mgm./l. of decumbin in 10 per cent ethanol. Eight goldfish (*Carassius auratus*), average weight 1·7 gm., were each placed in 250 ml. of a filtered aqueous solution of decumbin containing 0·6 mgm./l. In about 4 hr. they became noticeably inco-ordinated. Death followed in about 20 hr.; the smallest (0·9 gm.) succumbed in 12 hr., the largest (2·95 gm.) in 29 hr. Three other fish which had developed definite symptoms (6 hr.) were removed to fresh water; one survived. Control fish in 250 ml. of distilled water remained normal. Young (approximately 100 gm.) albino rats (*Rattus norvegicus*, Wistar–Purdue strain) were fed measured doses of decumbin mixed with about ½ gm. of their normal diet. Fasted rats ate the material readily and consumed the entire dose. From a total of 38 rats dosed with 400 mgm./kgm. body-weight or more, only one rat survived. The toxic symptoms included a rapid onset of loss of appetite (about 2 hr) and diarrhœa (about 6 hr.), followed by increasing lethargy and finally cyanosis, laboured breathing, stupor, and death in about 24 hours. Many rats had slight nasal bleeding. The typical autopsy findings included congestion of the auricles and associated blood vessels with dark blood and fullness of the stomach with undigested food. Ten rats received a dose of 300 mgm./kgm. and two survived. All five rats which received 250 mgm./kgm.

survived. The rats that survived began to eat in about 36 hr. and became apparently normal in five days or less. The acute, oral *LD*50 for rats would be of the order of 275 mgm./kgm. based on these results. Hydrogenated decumbin was not toxic to two rats at 2,700 mgm./kgm. The physiological activity or toxicity of decumbin in mammals, cold-blooded animals and plants is similar to that found with other unsaturated lactones and the loss of toxicity upon hydrogenation is also typical[1].

In addition to its interest as a new compound and one with physiological activity, decumbin was considered as a possible though uncommon grain contaminant. The results of feeding tests with corn meal infected with this mould suggest that decumbin is produced, but not to a degree highly toxic to rats.

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Muscle Fibres of the Fast and the Slow Contracting Muscles of the Mesothoracic Leg of the American Cockroach (*Periplaneta americana* L.)

It is well known that some muscle fibres in the coxa of the mesothoracic leg of the American cockroach contract rapidly while others contract slowly[1,2]. Until recently the difference in contraction-speed of insect muscles was attributed mainly to a difference in innervation. Krüger[3], however, discovered that in vertebrates the structures of fast and slow muscles did not differ only in degree of innervation. The specific locomotory muscles apparently consist of fibres that show a uniform distribution of the myofibrils in cross-section (*Fibrillenstruktur*), whereas in posture muscles the fibrils are in small groups, in which the individual muscle fibres are sometimes scarcely discernible. These groups often form angular areas (*Feldstruktur*). The question now arises whether similar differences occur in insect muscles. In order to investigate this problem some muscles of the coxa have been examined in cross-section. They were fixed in 15 per cent formol, Champy, Susa and Bodian 2, and embedded in the usual way in paraffin (alcohol, methyl benzoate, benzol, benzolparaffin). For frozen sections the muscles were embedded in 15 per cent gelatine.

Examination of the whole muscle in cross-section shows that the muscle fibres do not all have the same structure. Two types may be distinguished.

Type A. Muscles 136 and 137 (Carbonell's numbering[4]). In the periphery of the fibres radially arranged partitions are observed, wherein, at greater magnification, the sarcostyles may be discerned. The protoplasm between the sheets is of a lighter colour.

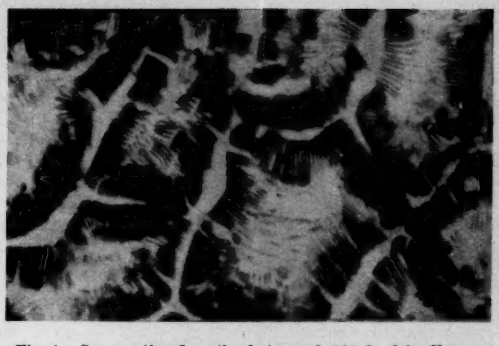

Fig. 1. Cross-section from the fast muscle 137 fixed by Champy paraffin section, iron–hæmatoxylin stain. (× 540)

Fig. 2. Right, cross-section from the fast muscle 136. Left, from the slow muscle 135 *e*, fixed by Bodian 2, frozen section, sudan black stain. (× 540)

In the middle of the fibre is a large central lumen. The nuclei are always situated in the layer of sarcoplasm just under the sarcolemma. This picture is obtained both in paraffin and in frozen sections (Figs. 1 and 2). The radial arrangement is not always equally clear and sometimes not one can be seen in the whole fibre. Fibres without a central lumen are always smaller than the others in cross-section and their fixation is different.

Type B. Muscles 135 *b*, *d* and *e*. In paraffin sections the fibres of these muscles generally have no central lumen. The sarcostyles are not radially arranged in partitions, but are either arranged in arbitrary rows or scattered all over the fibres. Cross-sections (Fig. 3) show these fibres to be smaller than those of Type *A*. In frozen sections, however, a central lumen is found not infrequently, in which case the sarcostyles are radially arranged (Fig. 2).

Fig. 3. Cross-section from the slow muscle 135 *d*, fixed by Bodian 2, paraffin section, stained with hæmatoxylin and eosin. (× 540)

With sudan black the fibres of muscles 135 *b*, *d* and *e* stain darker than those of muscles 136 and 137, moreover, with methylene blue the reducing capacity of 135 *b*, *d* and *e* is stronger than that of 136 and 137. As was the case with Type *A*, the nuclei of this type are situated in the layer of protoplasm right under the sarcolemma. Occasionally, however, they may be found nearer the centre of the fibre.

Muscles 135 *a* and *c* do not always give the same picture as 136 and 137; generally these are identical, but in some cases there is a closer resemblance to 135 *b*, *d* and *e*. This phenomenon was observed especially after fixation in Bodian 2.

According to Becht and Dresden[2] the muscles 136, 137 and 135 *a* and *c* are fast-contracting, and 135 *b*, *d* and *e* slow-contracting. The observations described above show that in frozen sections both the slow and the fast muscles are of Type *A*, whereas in paraffin sections the fast muscles are for the greater part of Type *A*, but the slow muscles are always of Type *B*. This difference can be explained only in terms of a different reaction with the fixation liquids, alcohol, methyl benzoate, benzol and paraffin.

This seems to indicate a difference in physico-chemical composition that causes the slow muscles to shrink more under the influence of the fixation liquids than the fast ones and that also causes the radial arrangement of the sarcostyles to be lost. Moreover, it is evident that the fibres of the slow muscles contain more lipoids and water and have a stronger reducing capacity than the fibres of the fast muscles.

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Masculinizing Action of Pregneninolone on Female Gonads in the Cyprinodont, *Lebistes reticulatus* R.

Several authors have tried to induce sex inversion in *Lebistes reticulatus* experimentally by the use of sex hormones. Berkowitz[1] found that a high percentage of males treated from birth with œstrogenic substances developed ovotestes. The expected result with androgenic hormones would be the production of ovotestes in treated females. Treating young from birth, for a period of two to three months, Eversole[2] and Gallien[3] arrived separately at the same conclusion: that pregneninolone causes the ovaries to undergo a considerable regression, but that they always keep their female structure. Gallien added that after the cessation of treatment the ovaries returned to normal.

Suspecting that their failure to produce masculinization of the gonads was due to the relatively short duration of their experiments, and to the excessively high dose of pregneninolone used, we have carried out the following experiment: 55 animals, all the same brood of *Lebistes*, were treated from birth for a period of 6 months. Treated animals were divided into two groups: the first was given a high dose of 0·03 mgm. of pregneninolone (Ethistérone, UCLAF), three times a week. The second received a low dose of 0·015 mgm. of the same hormone, thrice weekly. A third group of control animals was raised in a manner identical with the treated ones. At the end of the experiment, histological examination of gonads showed that out of 55 treated animals, 37 were males, 15 possessed hermaphrodite gonads and 2 were typical females. Out of 16 control fish, we found 11 males and 5 females.

All treated animals, regardless of sex, showed a transformation of the anal fin into a more or less typical gonopodium. Gonopodia of treated animals were shorter than those of the control ones, and those of the high-dose group were shorter than those of the low-dose group. Specific characters of the gonopodium were present (that is, ventral and dorsal spines, as well as the terminal hook). There were not so many in treated fish as in the controls. Terminal bifurcations, normally found in both sexes, on the fourth, fifth and sixth rays of the anal fin, were partially or completely absent in treated animals. Treatment inhibited growth to a great extent, in both sexes. While treated males had typical body colorations, females had few, if any, body pigments, and when present they were very pale.

The first hæmal spine persisted in all treated animals except one; normally this regresses in both males and females[4,5]. This spine has the same morphology as the following hæmal spines. In almost all treated animals, the gonactines (interhæmal spines) have normal male morphology; in the others the gonactines are completely welded together.

The chronology of development between different secondary sexual characters is disturbed in many cases, due to an acceleration in the development and differentiation of the gonopodium with regard to internal suspensorial elements.

Treated males have testes more or less normal in structure, but in the high-dose group there is an obvious stimulation of spermatogenesis, in such a way that late stages predominate. Sperm ducts are more numerous than in control testes, and their epithelium seems to be highly stimulated.

Gonads of all treated animals, presumed to be genetic females (except two), are transformed into ovotestes. These gonads show different degrees of masculinization. Male elements existing include cysts of spermatogonia, spermatocyte I and II. Cysts of spermatids are less numerous, and spermatophores are rare; whenever present, these are abnormal in structure. In the ovotestes, a certain number of tubules can be distinguished, probably deriving from the epithelium of the ovarian cavity. These tubules are the homologues of sperm-ducts in female gonads. The cranial region of gonads seems to be more sensitive to the masculinizing action than the posterior region, which sometimes maintains its typical ovarian aspect. In most cases, the persisting ovarian cavity is much expanded. Besides these male elements, and side by side with them, cysts of oogonia, and ovules at different stages of development, can be distinguished. Fully mature ovules are exceptional. Atrophied follicles appear here and there in the gonad.

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Preservation of Hæmocyanin

THE hæmocyanins are important proteins since they contain a marker atom (copper) and are remarkably good antigens. Since other investigators may wish to prepare and preserve hæmocyanins, we wish to direct their attention to our observations. In the course of experiments with preparations from *Busycon canaliculatum* and *Limulus polyphemus*, we noted that the dry product obtained by lyophilization (freeze-drying) could not be dissolved in water, in 0·85 per cent saline or in Tyrode's solution (*p*H 3·0–11·0). The hæmocyanin had also lost its oxygen-binding capacity and no longer turned blue when exposed to air. On the other hand, we have kept serum containing hæmocyanin at 4° C. under a layer of toluene, and find that it has retained antigenicity in guinea pigs, rabbits and mice after as long as ten years storage.

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Detection of Polythionate in Cultures of *Thiobacilli* by Means of the Folin–Ciocalteu Reagent

A SUBSTANCE giving a typical blue colour with the phospho-tungstate–phospho-molybdate reagent of Folin and Ciocalteu[1] was found to accumulate in cultures of *Thiobacillus thioparus* and *T. thiocyanoxidans* growing in a medium containing thiosulphate. The component in question was not associated with the bacterial cells since it remained in the supernatant fluid of cultures centrifuged at high speeds. The possibility suggested itself that the material involved was an oxidation product of thiosulphate, possibly tetrathionate or one of the other polythionates. These compounds have been reported to be intermediate oxidation products of thiosulphate by the *Thiobacilli*[2].

Polythionate was found to form in cultures of both species when culture fluids were analysed by means of Starkey's qualitative test[3]. This test depends upon the action of potassium hydroxide on the polythionates, converting them to mixtures of thiosulphate and sulphite, products which can be estimated by titration with iodine. Increased titration values during the incubation of cultures would indicate in a general way an increase in the amount of polythionate. The formation of trithionate at the expense of the other polythionates would confound this observation, since this compound on treatment with potassium hydroxide gives a higher iodine titration than do the others. The production of the Folin–Ciocalteu reactive substance was found to parallel the accumulation of polythionate. This was especially noticeable in cultures of *T. thiocyanoxidans*, which failed to produce any reactive substance until late in the incubation period (Table 1).

Sodium tetrathionate was prepared according to the technique described by Partington[4] and was purified by two recrystallizations from ethyl alcohol. The phenol reagent was readily reduced by the purified salt, which was very nearly as active in this capacity as tyrosine. Sulphite also reduced the reagent, but was considerably less active than tetrathionate (Table 2). If formalin were present during the reaction, the colour produced by sulphite was completely eradicated and the density of that produced by polythionate was reduced. The activities of these two substances differ from each other to such an extent as to make untenable the seemingly likely explanation that the mechanism involves the formation of sulphite from tetrathionate. That some alteration does occur was indicated by the necessity for the pre-incubation period in the alkaline copper solution of the usual Folin–Ciocalteu procedure.

Table 1. POLYTHIONATE ACCUMULATION IN CULTURES OF *T. thioparus* AND *T. thiocyanoxidans* AND THE FORMATION OF THE FOLIN–CIOCALTEU-ACTIVE SUBSTANCE

Organism	Incubation (days)	Polythionate*	Optical density of blue colour
T. thioparus	0	0	0·00
	3	40	0·36
	4	90	0·53
	5	84	0·60
	7	69	0·51
T. thiocyanoxidans	0	0	0·00
	3	0	0·00
	4	0	0·00
	5	15	0·24
	7	31	0·31

* Expressed as microequivalents of iodine per 5 ml. of culture fluid. The cultures were grown in Roux bottles containing 50 ml. of medium[3]. Individual cultures were used for the daily analyses. The optical density measurements were made using the 'Unicam model *SP.*500' spectrophotometer. Wave-length, 500 mμ.

Table 2. RELATIVE CHROMOGENIC ACTIVITY OF TYROSINE, TETRATHIONATE, SULPHITE AND CULTURE FLUID. EFFECT OF FORMALIN

Sample	Optical density of colour formed Without formalin	With formalin
Tyrosine, 0·5 μ*M*	0·40	0·39
Tetrathionate, 1·2 μ*M*	0·35	0·19
Sulphite, 30 μ*M*	0·43	0·02
Culture fluid, 1·0 ml.	0·35	0·17

The optical density was measured in the Klett–Summerson photometer, employing the No. 47 filter. The culture fluid was a sample from a culture of *T. thiocyanoxidans* grown for five days in the usual thiosulphate medium, except that it contained a reduced concentration of phosphate. The medium after incubation was centrifuged for 30 min. at 10,000 r.p.m. and the supernatant was used for analysis.

The material formed in the culture fluids was found to behave toward formaldehyde in much the same way as tetrathionate; however, further work is needed to identify the culture material positively as a particular polythionate.

The use of the Folin–Ciocalteu reagent appeared to give an easy procedure for indicating the presence of polythionates in bacterial cultures. Its use for more quantitative purposes will require further study to determine the relative reactivity, if any, of the polythionates other than tetrathionate. Possibly alteration of the reagent and procedure would enhance its specificity.

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A Ripple Effect in the Audiogram

In the course of some psycho-acoustic experiments it was found that one observer's thresholds of acuity at two frequencies separated by only a few tens of cycles differed by nearly 10 decibels. Dips in an audiogram are not uncommon; but the difference observed pointed to an uncommonly sharp change of sensitivity. Further tests revealed other equally sharp fluctuations in this observer's audiogram. Eventually a systematic exploration of the right-ear thresholds of this and one other observer was undertaken. Thresholds were measured at 10-cycle intervals over the range 400–3,000 c./s.

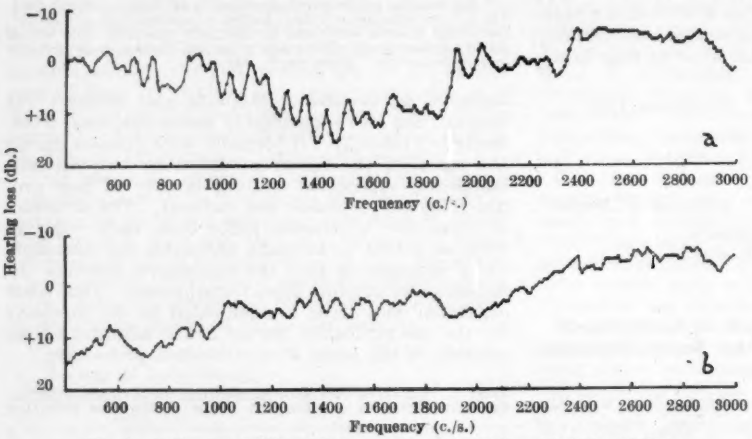

Fig. 1. Audiograms (*a*) for subject *A*, aged 21, and (*b*) for subject *B*, aged 28 years

The remarkable feature of these audiograms (Fig. 1) is the appearance of distinct ripples covering the range of frequencies up to about 2,000 c./s. Further experiments showed (1) that the ripples were stable over a period of at least two months, (2) that the left-ear audiograms also showed ripples, but the periods and amplitudes differed, and (3) that the ripple effect must be a very common, if not a universal phenomenon, since three additional observers also had the same sort of rippling audiograms in the narrower band from 1,000 to 1,400 c./s. This ripple phenomenon seems to have been unnoticed hitherto.

Threshold sensitivity fluctuates quite widely from one test session to another, and even within a single session if it is at all prolonged. To demonstrate the ripple effect it was necessary, therefore, to keep the test sessions short; but each session included measurements of threshold at frequency intervals which were small compared with the period of the ripple, and the frequency band covered was more than twice the period.

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Magnitude of Discomfort caused by High Brightness

Hitherto the greatest care has been taken here in the studies of building efficiency to avoid methods of subjective judgment which depend on assessment of sensation magnitude in terms of numbers. For certain reasons, however, a numerical assessment of the magnitude of the sensation of discomfort due to glare was required.

An experiment was designed in which subjects, so far as possible naïve in the context, were asked to adjust conditions in a room with glaring light sources until the sensation of discomfort was 'twice', 'ten times', 'one-half' and 'one-tenth' of the original level of discomfort. Eight out of twelve subjects were able to make judgments without trouble, the other four being either unco-operative or unable to follow what was required of them. The results were consistent and showed less variance than expected. The precise relations, which will be reported elsewhere, are not of importance in the present context because they depend on the experimental conditions.

It is of interest, however, that discomfort magnitude was found not to be correlated linearly with (apparent) brightness of the glaring sources. Whereas, under the given conditions of adaptation, apparent brightness was known from previous work[1] to be related to photometric brightness (luminance) by a power law of the form:

$$M = k L^{0.5}$$

where M is apparent brightness magnitude and L is luminance, the magnitude G assigned to the glare discomfort was found, under essentially the same conditions, to follow a law

$$G = k L^{1.23}$$

In other words, whereas the luminance of the sources must be raised four times $\left(\text{antilog}\ \frac{\log_{10}2}{0.5}\right)$ to appear twice as bright, the sources will appear twice as uncomfortable (for glare) if their luminance is raised only 1·8 times $\left(\text{antilog}\ \frac{\log_{10}2}{1.23}\right)$.

If these data are valid, it raises an important principle in practical engineering matters involving subjective judgments of magnitude, especially if this principle is applicable in other modalities, such as noise. This is, that if a stimulus gives rise to both a primary sensation (loudness or brightness) and also an associated secondary sensation (pain or discomfort), it does not follow that the magnitude of the secondary sensation is directly or simply linked to the magnitude of the primary sensation. Hence, if we wish to find out about discomfort or pain, we must assess discomfort or pain directly in relation to stimulus energy, and must not make implications from brightness or loudness magnitude assessments.

The experimental work was undertaken by Mr. R. C. Bradley (Cornell University) working at the Building Research Station with a grant from the Illuminating Engineering Research Institute of the United States.

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Interaction between Consecutive Responses in a Hemileucid Moth, and the Evolution of Insect Communication

Moths of the neotropical Saturnioid family Hemileucidae perform a special movement on assuming the resting position from any preceding activity, which has been termed 'rocking'[1]. It is rigidly co-ordinated, and consists of fast, rhythmic side-to-side oscillations of the entire animal. This movement is unique to the Hemileucidae, and appears to be a highly conservative character within that family, for it occurs in all species so far examined, irrespective of either size or mode of protective coloration[2]. Its function, if any, is unknown, but it is not concerned with the sexual responses of either sex, nor do the moths possess any known non-sexual social behaviour. The strength of this response may be scored as the number of complete oscillations performed; an analysis has shown that the strength of rocking executed by unconstrained moths of the Brazilian species *Automeris aurantiaca* Weym. is related to the nature of the sequence of acts preceding it[1].

The experiment here reported investigates the effect of different periods of forced, tethered flight upon the strength of the rocking response, at two different intervals after eclosion. Pupal development and emergence were allowed to proceed at about 25° C. Moths stored for intervals after eclosion were transferred to 20° C. in continuous artificial light and remained undisturbed throughout that period. They were suspended for flight in one of two ways. Either a small tab of paper was attached to the dorsal surface of the thorax with a quick-drying cellulose adhesive, and held in a clip, or a small dorso-lateral pinch of the second abdominal tergite was held in fine curved artery forceps, from which it could be released as required. The method of suspension did not influence the results. All moths were de-alated at the time of preparation. They were stimulated to fly at 26–29° C. by the tarsal reflex[3], at 4–8 hr. (26 moths) and 24–48 hr. (15 moths) after eclosion, immediately placed on a standardized vertical surface, and the number of rocks performed counted (Fig. 1). The strength of the rocking response increases with increase in preceding duration of flight, to which it bears a simple linear relationship which shifts as the moths age. For moths 4–8 hr. old, $y_1 = 2{\cdot}45 + 0{\cdot}790x$; and for moths 24–48 hr. old, $y_2 = -0{\cdot}75 + 0{\cdot}663x$. The difference between the two regression coefficients is not significant ($P < 0{\cdot}2, > 0{\cdot}1$).

Moths may be re-tested for the strength of the rocking response at intervals after settling following flight; in moths of both ages it is stable, certainly for periods of 30 min., and probably for at least 90 min., and would seem not to be affected by intercalated activities unrelated to flight. Further preliminary experiments, to be reported in full elsewhere, suggest that these relationships are not mediated either by feed-back from peripheral receptors[4] or by the chemoreception of the state of metabolic reserves[5].

Results of this kind have been obtained in studies of the behaviour of other arthropods[6]. They suggest that the arthropod nervous system may be so constructed as necessarily to store information about its past performance. The present case is of particular interest, for it concerns a rhythmic response. Recent work[7] tends to confirm the prediction[8] that the rhythmic 'waggle' phase of the honey-bee dance is a potentially important carrier of information about distance from hive to food-source when this is greater

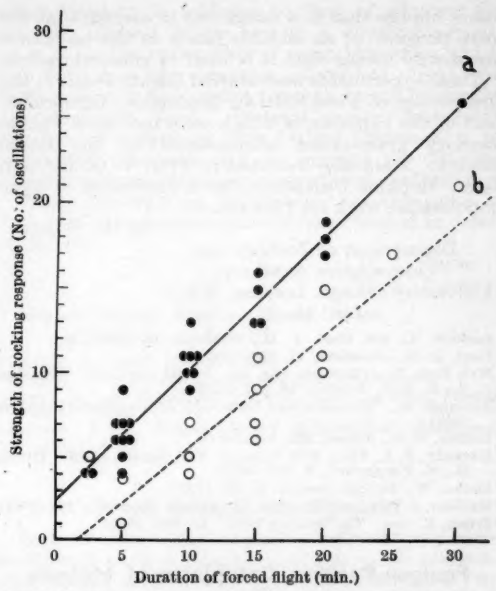

Fig. 1. The relation between the duration of forced flight (abscissa) and the strength of the rocking response (ordinate), for *Automeris aurantiaca* of two different ages: (*a*) 4–8 hr.; (*b*) 24–48 hr.

than 50–100 metres. The relationship between distance flown and the number of oscillations in each repetition of the straight run of the dance is simple and nearly linear over much of its range[7]; it differs from certain other quantitative features of the dance[9] in that it is not affected by the sugar-concentration of the food-source.

Dethier[5] has shown that those features of the bee-dance which show simultaneous dependence upon flight-distance and sugar-concentration may plausibly be interpreted in terms of the known mechanisms governing the central regulation of taste-thresholds, once it is assumed that feeding is itself the stimulus to dance. But such a mechanism cannot be assumed to mediate the 'waggle' phase of the dance in its quantal aspect, and for this some alternative evolutionary precursor must be found. Such a system would appear to be involved in the interaction between flight and settling behaviour in *Automeris*, which already possesses two of the most salient features of the 'waggle' dance, namely, the linear relationship described above, and a considerable measure of quantitative temporal stability. It is not, however, used in communication. It is likely that a full understanding of the causal basis of the bee-dance will only be possible when mechanisms of both kinds are taken into account.

The present results do not permit any very exact comparison of the two performances. However, if it is assumed that foraging bees fly at an average speed[4] of 14 m.p.h. ($\equiv$375·5 m./min.) and that both the outward and return journeys are registered in the waggle phase[7], then for the bee, 3·34 oscillations $\equiv$ 1 min. of flight, as compared with 0·79 oscillations for moths 4–8 hr. old. *Reproducible* information, therefore, is stored with less efficiency in the moths than in the honey-bee. These results emphasize a further problem: the presence of a teleologically perfect relationship of this kind in a non-communicating

insect implies that it is dangerous to assume that the mere presence of an isolable factor in the bee-dance necessarily means that it is used in communication.

These experiments were started during a visit to the Ornithological Field Station, Madingley, Cambridge, part of the expenses of which were met by a Parliamentary grant-in-aid administered by the Royal Society. I am also indebted to Prof. V. G. Dethier, Johns Hopkins University, for a discussion of some unpublished work on *Phormia*.

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Feulgen-Positive Cytoplasm of *Molgula* Eggs

The Feulgen technique has been used with success for chromosome studies in whole mounts of the eggs of marine animals such as *Arbacia* and *Chaetopterus*[1]. Hundreds of specimens can be fixed, stained and mounted in an hour or two—a fraction of the time and effort involved in an embedding-sectioning procedure.

Recently, in expectation of preparations suitable for scoring chromosomal aberrations (investigations supported by a U.S. Atomic Energy Commission grant to the Marine Biological Laboratory), I applied exactly the same methods to fertilized eggs from the ascidian *Molgula manhattensis*. To my surprise, the cytoplasm stained so deeply that nuclei and chromosomes were completely obscured. Several papers of historical interest[2] report intense cytoplasmic coloration of *Molgula* eggs with non-specific staining methods. However, deep staining with the classic means of demonstrating deoxyribonucleic acid was not expected.

A maturing series of oocytes carried simultaneously through the solutions demonstrated that the stainable material accumulated during maturation. Only mature oocytes stained deeply.

Substituting one fixative for another made little difference. The cytoplasm was Feulgen-positive if Gilson's fixative, which contains no aldehyde, was used instead of Kahle's fluid. Digestion with cold perchloric acid (10 per cent for 11 hr. at 4° C.) did not eliminate the cytoplasmic stainability. This is a recognized method of removing ribonucleic acid. The Schiff reagent was a standard batch which was performing normally in the staining of *Habrobracon* (wasp) eggs.

Brachet[3] has referred to positive Feulgen reactions of the ooplasm of higher chordates but was unwilling to admit that deoxyribonucleic acid could be responsible. Amphibian and hen eggs were outstanding examples. Since that time, scattered reports of cytoplasmic deoxyribonucleic acid or deoxyribosides have appeared for a variety of organisms[4], and a hypothesis has emerged that the cytoplasm serves as a deposit for nuclear building materials required promptly and in quantity during cleavage[5].

The cytoplasm of *Molgula* eggs suggests itself as material worthy of attention by biochemists interested in morphogenesis.

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Relation between Breeding and Ecdysis in Cirripedes

In all major groups of Crustacea except in cirripedes it is well known that breeding is closely bound up with the moulting cycle. First, the male generally copulates with a female which has just moulted. Secondly, the moulting cycle is often interrupted while the eggs are being carried so that eggs are not lost by the shedding of the cuticle to which they are attached.

The Cirripedia are exceptional in being hermaphrodite and in having the egg masses lying free in the mantle cavity during incubation. As a result they do not necessarily lose them when they moult[1]. Crisp[2] suggested that a moult might be expected to accompany copulation as it does in other arthropods. Barnes and Barnes[3] later discussed the same idea, and without giving any definite evidence suggested that it occurred after fertilization.

During the past three years we have investigated six species of sessile barnacles, *Balanus balanoides* (L.), *Balanus balanus* (L.) (= *B. porcatus* da Costa), *Balanus crenatus* Brugière, *Balanus perforatus* Brugière, *Elminius modestus* Darwin and *Chthamalus stellatus* Poli.

In none of these species have we found evidence for a moult soon after copulation. On the contrary, the intermoult period is prolonged when the barnacle is carrying embryos, although the extension of the intermoult period is not absolutely regular. Normally ecdysis does not occur until after the young have hatched and escaped from the mantle cavity.

When hatching is delayed by withholding food[1] the intermoult period is further prolonged so that in the majority of individuals moulting still occurs just after liberation. Sometimes the moulting cycle seems to reassert itself before liberation; but the eggs still develop normally and a further moult usually occurs after liberation. Very occasionally developing eggs are ejected from the mantle cavity; but this usually occurs under abnormal temperature conditions and is not necessarily related to moulting.

In *B. balanoides* the breeding cycle is long and the period of anecdysis, which commences with the copulation in November, lasts until sometime between December and March, varying with the individual (Fig. 1). In this species the first cast skin after the period of anecdysis, irrespective of whether fertilization has occurred or not, contains all the tissues of the penis. The penis is thus separated by an abscission layer of new cuticle, and a new penis gradually

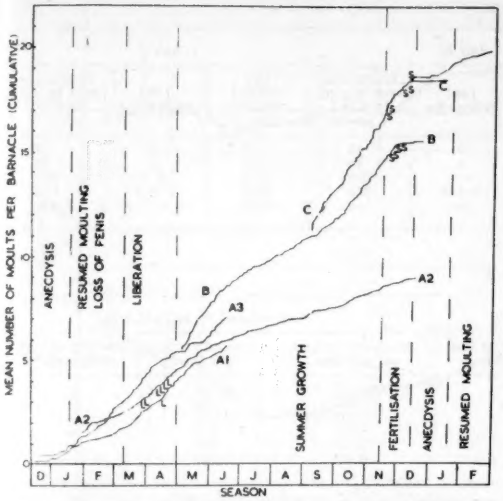

Fig. 1. Moulting-rate of small groups of *B. balanoides* kept without food. A_1, A_2, A_3, groups of fertilized barnacles showing resumption of casting after anecdysis; A_1, 5–7° C. temp.; A_2, sea temp. (8° C. rising to 15° C.; A_3, 13–15° C.; *L*, liberation of nauplii. *B*, groups of barnacles which had previously fed in the sea during spring. *C*, groups of barnacles fed in the sea until September, showing anecdysis; *S*, sperm pool indicating fertilizations

develops before the onset of the next breeding season. This remarkable phenomenon is natural, and is not the result of abnormal laboratory conditions. It occurs in the sea, since barnacles from the shore in January have either a complete penis or none at all. Moreover, it has been shown to occur regularly each year since 1954 in the laboratory and is therefore a part of an annual rhythm.

We have also found that individuals of this species which have moulted less than about a week previously are better able to act as females, fertilization occurring more frequently than in barnacles which had cast the skin more than a week before. In none of the other species could this effect be demonstrated, perhaps because the normal intermoult period of only 6–10 days is so short that every individual can be regarded as having recently moulted.

In *B. crenatus*, *B. perforatus*, *Elminius modestus* and *Chthamalus stellatus* embryonic development is relatively short, especially at higher temperatures, and after the brief interval for incubation normal moulting is resumed, its rate depending on the food supply and temperature. In *B. balanoides*, on the other hand, the moulting-rate only gradually increases after anecdysis, its resumption depending upon the amount of food taken in and the temperature. The inter-moult period usually reaches the normal summer value of 10–15 days by May. If the individuals are not fed in the spring, hatching is delayed and the resumed moulting continues at a slower rate (Fig. 1, curve A_2). The slower rate of moulting after anecdysis is not, however, a direct consequence of carrying the eggs but is due to prevailing lower temperature in April and lack of food. The moulting-rate does not increase appreciably when the eggs are artificially hatched with an extract of shell tissue[1]; but it does increase if the barnacle is fed or the temperature raised.

The continued regular casting of starved specimens which are losing rather than gaining weight is interesting. It suggests that ecdysis may have another function in addition to that of allowing for growth. Indeed, where casting is disadvantageous, as it is for the caterpillars of some butterflies which live with ants (for example, *Maculinea arion*), the body can grow four or five times in length by simply stretching the skin[4]. Perhaps another important function of ecdysis in filter-feeding Crustacea is to renew the fine setæ and so prevent the filtering apparatus from becoming clogged and inefficient.

These observations, which bring the Cirripedia in line with other arthropods, will be published in detail elsewhere.

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Plant Growth on 'Fly Ash'

In a previous communication[1], reference was made to research work in progress at Leeds on the reclamation of land covered with pulverized fuel waste ('fly ash'). Further to that work, we have concluded that aluminium and manganese, as found by Rees and Sidrak[2], are not the dominant causes of the toxicity in the 'fly ashes' investigated at Leeds.

Evidence from records on the tolerances of crop plants to 'fly ash', together with observations of leaf symptoms, suggest that boron is the dominant toxic element, and this theory has been strengthened by direct agronomic tests, together with relevant chemical analyses. The evidence is summarized below.

Information gained from pot and plot experiments has enabled a preliminary classification of agricultural and horticultural crops into the following three main groups on the basis of their ash tolerance:

Tolerant: Fodder beet, mangels, red beet, spinach, swede, turnip and sweet clover.

Moderately tolerant: Clovers, lucerne, kales, rape and mustard, other cultivated members of the Cruciferæ and ryegrass.

Sensitive: Cereals (especially barley), peas, vetches, beans, potatoes, lettuce, carrots, parsnips, buckwheat and cocksfoot.

This list bears close resemblance to those of Eaton[3] and Berger[4], who grouped crops according to their boron tolerance.

Visual symptoms which develop on plant leaves under conditions of boron toxicity have been described by Eaton[3]. There is a close similarity between the recorded symptoms and those which have been observed on plants grown in 'fly ash', although the leaves of beets and kales in our experiments have not shown the characteristic marginal scorch. Barley

Table 1

Conc. of added boron in borax solution (p.p.m.)	Severity of leaf symptoms	Dry weight of plants (gm.)	Boron content of plants (p.p.m. in d.m.)
0	0	1·29	28
10	+++	1·11	248
20	+++	0·90	626
40	++++	0·64	1,738
60	++++	0·40	2,860
80	leaves dying	0·21	3,280
100	leaves dying	0·15	4,415

Table 2

Percentage ash (by vol.) added to soil	Ash *A*			Ash *B*			Ash *C*		
	Dry weight plants (gm.)	Leaf symptoms	Boron content (p.p.m. in d.m.)	Dry weight plants (gm.)	Leaf symptoms	Boron content (p.p.m. in d.m.)	Dry weight plants (gm.)	Leaf symptoms	Boron content (p.p.m. in d.m.)
0	1·22	0	17	1·27	0	15	1·35	0	18
12½	1·42	0	48	1·56	+	65	1·45	+	95
25	1·44	+	100	1·40	++	200	1·32	++	206
50	1·38	++	213	1·03	+++	351	1·02	+++	518
100	—	—	—	—	—	—	0·74	++++	1,420

Table 3

Percentage ash *C* added by volume to sand/vermiculite	Untreated fly ash *p*H 9·0			Acid-treated fly ash *p*H 6·1		
	Mean dry weight per pot (gm.)	p.p.m. of boron in d.m.	Severity of leaf symptoms*	Mean dry weight per pot (gm.)	p.p.m. of boron in d.m.	Severity of leaf symptoms*
0	4·66	44	0	5·14	33	0
6¼	3·26	260	+	5·11	75	0
12½	2·55	313	++	5·26	138	0
25	1·40	643	++++	4·89	310	+
50	0·82	796	++++	3·76	367	+
100	1·05	433	++++	0·40	1,246	++++

Dry weights L.S.D. = 1·07 gm. ($P = 0·05$); boron content L.S.D. = 117 p.p.m. ($P = 0·05$).
* Mild leaf symptoms took the form of leaf tip die-back, severe symptoms showed in addition a white interveinal striping of the lamina.

leaves, however, have consistently developed the marginal scorch, leaf tip die-back and brown necrotic spots and blotches associated with boron toxicity. Christensen[5], investigating the cause of non-parasitic spotting of barley leaves, was able to reproduce the spotting experimentally by adding borax or boric acid to a soil which otherwise produced healthy plants. The lesions which occur on barley leaves under conditions of manganese deficiency and toxicity[6] do not appear to be typical of those caused by 'fly ash'.

A small, non-replicated pot experiment was designed to compare the growth of barley on 'fly ash'/soil mixtures and on soil irrigated with solutions of borax. Three 'fly ashes', *A*, *B* and *C*, were used in this experiment. The leaf symptoms which developed on plants grown in 'fly ash'/soil mixtures were identical to those developed on the boron-irrigated plants. The 'soil' results are presented in Table 1 and the 'ash' results in Table 2.

Further evidence of boron toxicity has resulted from chemical analyses of oats from a replicated pot experiment specifically designed to compare the toxicities of untreated and acid-treated 'fly ash' when incorporated in increasing quantities with an inert medium of sand and vermiculite. The dry weights of oats, their boron contents and leaf symptoms are summarized in Table 3.

The accumulated evidence suggests that boron is a major component of the 'toxic principle' in 'fly ash' and determinations of the water-soluble boron contents confirm that this element is present in high concentration, samples *A*, *B* and *C* containing 19, 18 and 51 p.p.m. respectively. The degree to which the toxicity manifests itself will be dependent partly on the source of the ash and the degree of weathering or leaching to which it has been subjected. It must be emphasized that work referred to in this communication has been carried out on unweathered ash, that is, that taken directly from the pulverized fuel furnaces. (Boron has been determined after Higgons[7].)

This work has been made possible by a research grant to the University of Leeds by the Central Electricity Authority to which full acknowledgment is made.

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Effect of a Single Light Exposure on Germinating Broad Bean Seeds

In the course of investigations into the cytological and anatomical aspects of etiolation in *Vicia faba* L. (broad bean), experiments were carried out to determine the stage at which the germinating seeds first become sensitive to light in regard to subsequent development of the internodes.

Seeds were soaked for 24 hr., planted in soil and grown for 12 days. Throughout the period of soaking, during planting and for the whole period of growth the material was kept at 20° C. and in complete darkness, except for a single exposure to light for 2 hr. at approximately 600 ft.-candles. The seeds were divided into batches of fifty, each batch being given a single exposure to light, starting at various intervals up to 7 days from the beginning of soaking. As a control, one batch was given no light. The internode length of all seedlings was measured at the end of the 12-day growth period. Fig. 1 summarizes the results.

At 12–14 hr. after the beginning of soaking, when the testa is still intact, a 2-hr. exposure to light gives rise to a reduction of approximately 15 per cent in the mean ultimate length of the first internode as compared with seeds soaked and grown in complete

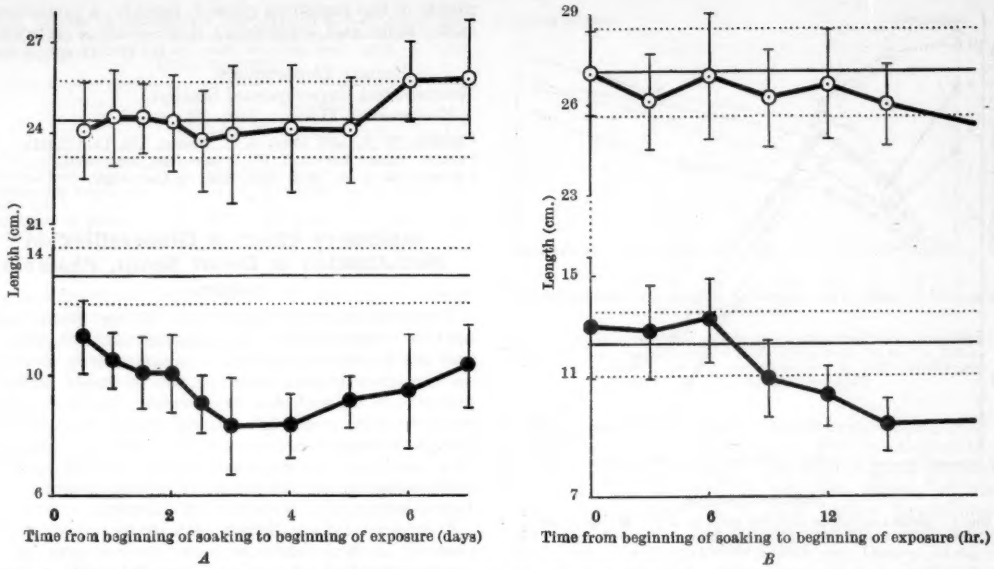

Fig. 1. Effect of a single light exposure on germinating seeds. ○—○—○, Whole shoot; ●—●—●, first internode. The vertical bars indicate the fiducial limits at the $P = 0{\cdot}05$ level. The horizontal lines represent the dark control values and their fiducial limits

darkness. The reduction reaches a maximum of approximately 35 per cent when the light is given at 3–4 days.

From the results it appears likely that the sensitivity to light may develop earlier than 12 hr. This view is supported by the observation of a pronounced increase in the frequency of plants in which a third internode elongates after an exposure to light as early as 6–8 hr. This development of the third internode, coupled with a general increase in the length of the second internode after early light treatment, appears to compensate for the reduction in length of the first internode, so that the effect of light is not revealed in the ultimate total length of the shoot.

The situation seems to be similar to that shown in *Avena* by Lange[1], Avery *et al.*[2] and Goodwin[3]. Thomson[4], also working on *Avena*, concludes that light accelerates whatever growth processes are going on while the light stimulus acts, exposure early in the course of either cell division or cell elongation accelerating that phase of growth. Exposure when either phase is well under way hastens transition to the next phase and reduces the final number or length of cells. The first internode in *Avena* is thus suppressed by light given at one day or earlier when cell division is already in progress.

In *Vicia*, however, the light sensitivity, as revealed by suppression of the first internode, appears to develop in the partially soaked, intact seed immediately the embryo has taken up water, although no cell division was observed until the third day. It may well be that sensitivity has already developed in the maturing seed and is one of the factors contributing to the great variation in development within batches of seeds germinated and grown in the same conditions. This possibility is being investigated.

Apart from these considerations, the practical implications of our findings for etiolation and light-growth studies is that seeds must be soaked in complete darkness if a true picture of the completely etiolated plant and the effects of light during subsequent growth is to be obtained.

This work is supported by the Nuffield Foundation.

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Effect of Gibberellic Acid and Kinetin on Growth of the Primary Leaf of Dwarf Bean (*Phaseolus vulgaris*)

In the course of experiments on the effect of gibberellic acid on leaf area it was found that this substance accelerated expansion of the primary leaf of dwarf bean (var. Canadian Wonder); but the final area attained was identical with that of leaves receiving no treatment. Kinetin (6-furfurylaminopurine), on the other hand, depressed the rate of leaf expansion. Areas were estimated by use of a regression equation relating to the product of length × breadth calculated from measurements of more than 100 leaves. This equation is: area (cm.^{2}) = $0{\cdot}8682$ ($\pm$ $0{\cdot}0196$) × p + $3{\cdot}19$, where p is length × breadth in cm.^{2}. The application of the allometry formula indicated that treatment produced no change in shape of leaf, so it is justifiable to apply this regression equation irrespective of treatment. The leaves were sprayed as soon as they had unfolded and assumed a horizontal position (length about 5·0 cm.), and were kept in darkness for about 16 hr. in case kinetin was destroyed by light. The average daily increments in area plotted for the mean period are shown in Fig. 1.

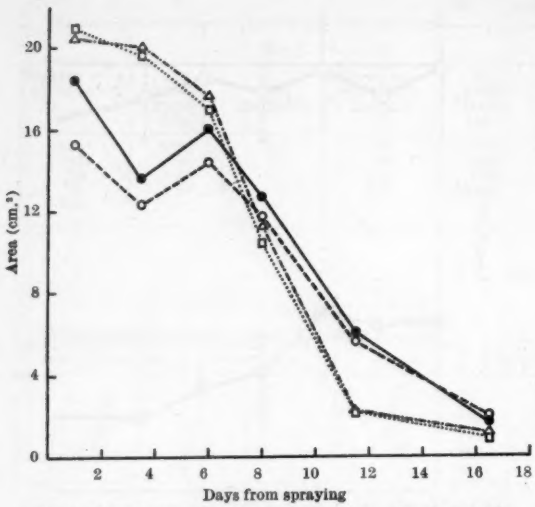

Fig. 1. Mean increase in area per leaf per day. ●—●, Control; ○—○, kinetin; △···□, gibberellic acid; △—•—△, gibberellic acid + kinetin

Leaves sprayed with gibberellic acid (50 p.p.m.) or gibberellic acid + kinetin (0·1 p.p.m.) at first increased in area at a greater rate than the control. Kinetin alone slightly depressed the rate of leaf expansion. About six days after spraying, the position was reversed and the control and kinetin-sprayed plants increased in area at a greater rate. The final area of the leaves sprayed with gibberellic acid was the same as that of the controls, but kinetin alone depressed final area (Table 1).

Table 1. Mean Final Area of Primary Leaf of Dwarf Bean

Treatment	Final area (cm.²)	
	a	*b*
(−)	61·4	205·6
Kinetin	54·8	187·5
Gibberellic acid	62·4	199·4
Kinetin + gibberellic acid	61·2	202·4

a, Growing point intact; *b*, growing point removed.

It is to be noted that the depressing effect of kinetin was overcome in the presence of gibberellic acid. It was thought possible that the growth of the primary leaves might be affected by initiation of growth of the main axis (which was greatly extended by gibberellic acid) and that the subsequent depressing effect of gibberellic acid might be due to this. Precisely similar results were obtained, however, when the growing point was removed before treatment, except that the primary leaves in all treatments reached a greater final size (Table 1).

Morgan and Mees[1] found that gibberellic acid at first stimulated growth of grass swards but afterwards the yield was depressed and the dry matter and crude protein yields at the second cut were depressed by approximately the amount of increase at the first cut. Leben and Barton[2] also found an ultimate depressing effect of gibberellic acid on growth of grass. Humphries[3] found that gibberellic acid at first increased and then diminished leaf area and dry-matter production in the potato plant. In addition, it was found that gibberellic acid overcame a depressing effect due to kinetin.

Thus, the effect of gibberellic acid on the primary leaf of dwarf bean is analogous to its effect on whole plants in the instances quoted, namely, a preliminary stimulation and subsequent depression of growth.

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Inhibitory Effect of Gibberellins on Nodulization in Dwarf Beans, *Phaseolus vulgaris*

Gibberellins of fungal and higher plant origin are now widely used in experimental plant physiology, and are known to produce a great variety of effects on the growth and development of many different plants[1]. With very few exceptions, the effects noted are promotive, even high concentrations of gibberellins being relatively non-toxic, to both plants and animals[2]. The results to be reported in this communication, demonstrating an inhibition of nodule formation in dwarf beans, are therefore of interest.

Commercial dwarf beans (*Phaseolus vulgaris*) were planted in 3-in. clay pots containing potting soil supplemented with limestone. The plants were grown in a greenhouse uncontrolled as to temperature and light conditions. On the sixth day after planting, the pots were divided into 5 equal groups of 4 plants each, and on the seventh day each plant was watered with 20 ml. of a 1 : 500 (w/v) 15 : 15 : 15 fertilizer to ensure an adequate level of mineral nutrition during the growth experiment.

Eleven days after planting, when the mean height of the plants approximated 15 cm., the groups were sprayed, according to different schedules, with 'Gibrel', a Merck product containing 0·005 per cent potassium gibberellate in an aerosol preparation. Thirteen days later, the plants were carefully removed from the soil and various measurements made. The results are presented in Table 1. Among the notable effects of the gibberellin treatments are: (*a*) up to fourfold enhancement of elongation without significant effects on fresh weight; (*b*) enhanced lateral bud growth; (*c*) decreased dry weight in plants given daily sprays; (*d*) greatly decreased nodulization, especially in those plants subjected to daily sprays.

Table 1. Effects of Repeated Applications of Potassium Gibberellate on *Phaseolus vulgaris*. All Plants were Examined on the Thirteenth Day of Growth after Spray Application

Group	Spraying schedule	Average height to terminal bud (cm.)	Average lateral bud growth (cm.)	Average fresh weight (gm.)	Average dry weight (gm.)	Degree of nodulation
A	Controls (no spray)	27·5	27·5	8·8	2·0	Numerous large clusters
B	Every 5th day	112·75	148·75	11·2	2·1	6–8 small nodules per plant
C	Every 4th day	93·25	93·25	8·1	2·1	9 small nodules on one plant
D	Every 3rd day	100·0	145·0	8·2	2·2	5–6 small nodules per plant
E	Every 2nd day	91·5	150·5	8·8	2·3	2 small nodules on one plant
F	Daily	93·5	159·5	9·4	1·5	None

Table 2. Effect of Gibberellin Applications to Soil Alone and to Plant and Soil. Measurements were made 19 days after planting, the plants having been sprayed only once, 5 days after planting

	Treatment		
	None	Soil only	Soil + plant
No. of plants	16	14	17
Terminal bud height (cm.)	24·2	36·6	75·0
Average dry weight per plant (gm.)	0·82	0·95	0·50
Percentage of plants showing nodulization	62·5	76·5	14·2

In a subsequent experiment, it was shown that gibberellin treatment of the soil was ineffective in inhibiting nodulization, though some growth effects were readily apparent. Gibberellin sprays applied to the plant and soil were more effective, both in increasing elongation and in decreasing nodulization (Table 2).

Although the mechanism of the inhibition of nodulization is not clear from these experiments, the results indicate the need for caution in the application of gibberellins to leguminous plants. They also suggest the possibility that nodulization may result from a local accumulation of gibberellins.

These experiments were performed as a project supplementing classroom exercises in plant physiology at a National Science Foundation-sponsored Summer Institute for Teachers held in the summer of 1957 at Iowa State Teachers' College at Cedar Falls, Iowa.

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Mitotic Delay in Irradiated Roots of *Vicia faba*: the Effect of Oxygen

It is well known that the presence of oxygen during the irradiation of biological materials by X- or gamma-rays usually increases the amount of radiation damage. At the cellular level a considerable amount of quantitative data exists on the effect of oxygen, given during irradiation, on the yield of chromosome aberrations[1], but little information is available concerning the influence of oxygen on the amount of mitotic inhibition. Early work on the fall in mitotic index values of broad bean root tips[2] and the more recent studies on mitotic rates of *Chortophaga* neuroblasts[3] and *Tradescantia* microspores[4] have all indicated that the degree of mitotic inhibition is dependent on the amount of oxygen present during irradiation.

We have investigated the oxygen effect on mitotic delay in broad bean root tips with the view of making a comparison with parallel results which we are obtaining for chromosome breakage and root elongation in this material. In our experiments gamma-rays from a cobalt-60 source were used, and the primary roots of seedlings were irradiated while maintained at

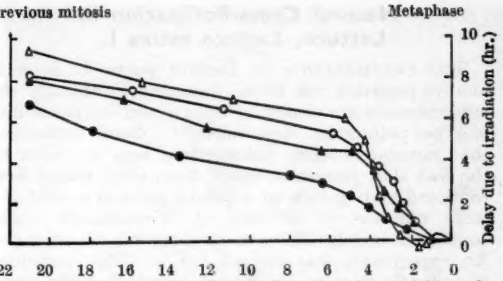

Fig. 1. Delay in reaching metaphase of cells irradiated at various stages of interphase. Normal mitotic cycle time, 21 hr. △, 192 r. in aerated water; ○, 109 r. in aerated water; ▲, 192 r. in nitrogen water; ●, 109 r. in nitrogen water

19° C. in aerated or oxygen-free water (nitrogen water, obtained by bubbling nitrogen). For irradiation the seedlings were transferred from their normal aerated water into the aerated or nitrogen water of the irradiation chamber for 5 min. before irradiation. Doses of 109 r. and 192 r. were used and both doses were given in 4·9 min. It was shown that a 10-min. immersion of control seedlings in nitrogen water did not affect mitotic rate.

Mitotic delay was measured by our colchicine method[5] which involved comparing the rate of accumulation of cells at metaphase in control material with the rates in the irradiated materials, at closely spaced time-intervals after irradiation. From these results we obtain the time required for cells to reach metaphase after being irradiated at any given point in interphase. The excess time over cells of control material, that is, the mitotic delay, is illustrated in Fig. 1.

The results show a marked oxygen effect for mitotic delay, and this effect is apparent for cells irradiated at any stage of interphase, the shape of the air and nitrogen curves being very similar. It is clear from these results that a dose of 192 r. in nitrogen is less effective in delaying the progress of cells through the mitotic cycle than a dose of 109 r. in air. Comparisons of the delays induced by both doses of radiation, in air and nitrogen, for cells which were more than 6 hr. from metaphase at the time of irradiation, gives an air/nitrogen ratio of about 2. This compares with the air/nitrogen factor of 2·4 for inhibition of root growth[6] and the factor of 2·2–2·5 which we have found for the production of micronuclei.

Further details of these experiments will be published elsewhere.

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Natural Cross-Pollination in Lettuce, *Lactuca sativa* L.

Self-fertilization in *Lactuca sativa* L. is commonly regarded as being complete, although the inflorescences are visited by insects and the possibility of cross-pollination does occur[1,2]. Some indication that natural crossing takes place was provided by the fact that progenies raised from seed, taken from random plants grown in adjacent plots of a trial of a large number of varieties at Wellesbourne, have contained widely different proportions of off-types. An experiment was carried out in 1955, therefore, to ascertain the amount of crossing which might occur.

Two varieties were planted in each of four plots, these consisting of 15 rows of 11 plants, the odd rows and alternate plants in the even rows being of a pigmented variety, while the remaining plants were of an unpigmented variety. Each unpigmented plant was thus surrounded by 8 pigmented ones. The gene for anthocyanin pigmentation[3] behaves as a dominant in F_1.

The first plot contained two winter lettuce varieties which flower rapidly in long days[3], while the second plot, which was sown at the same time as the former, contained two varieties of summer lettuce. The remaining two plots consisted of the same varieties of summer lettuce as the previous one, but were sown at three-weekly intervals. The flowering periods of all plots differed from one another, and times of flowering within plots were made to coincide by the removal of any capitula from unpigmented plants which opened before those of the pigmented ones. Seed collected from the unpigmented plants was sown in 1956 and the number of pigmented and of non-pigmented seedlings was recorded.

The weather in 1955 was dry and warm, encouraging insect activity; but the lettuce did not appear to have the same abundance of pollinating insects as brassica plants flowering in the vicinity. Insects most attracted by the open lettuce capitula were various species of hover-fly and a few butterflies. Bumble- and honey-bees were rarely seen on the plants. This comparative scarcity of insects suggested that the proportion of hybrids produced would be low, and this was confirmed by the results from the earlier flowering plants. The percentage of hybrids produced by the later flowering plants, however, showed a sharp increase as indicated in Table 1. It has been suggested by Mr. J. A. Dunn, of this station, that this increase was probably due to the seasonal rise in the hover-fly population, and it appeared probable that hover-flies were the main pollinators in this experiment with lettuce.

Unsuccessful attempts were made to use hover-flies as pollinators by enclosing them in muslin bags together with flowering lettuce plants; in every instance they made continual attempts to escape, and lived a maximum of only 36 hr.

Table 1

Plot No.	Varieties (pigmented variety first)	Flowering period	Mean per cent cross-pollination
1	Rouge à pomme dure d'hiver, Lees Immense	July 18–Aug. 26	0·75±0·053
2	Mignonette, Cheshire Green	Aug. 6–Sept. 8	0·15±0·009
3	Mignonette, Cheshire Green	Aug. 13–Sept. 16	3·19±0·186
4	Mignonette, Cheshire Green	Aug. 30–Sept. 26	11·52±2·749

The statistical analysis of the results showed that plants flowering late in the season exhibited a significant increase in the percentage of natural cross-pollination. With the exception of three plants in plot 3, cross-pollination during each of the different flowering periods was entirely at random.

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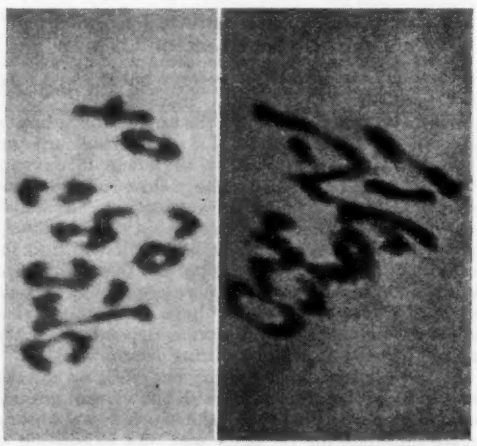
Sex Chromosomes in the Hop *Humulus lupulus*

Studies of meiosis in male plants of the hop *Humulus lupulus* have resulted in conflicting reports on the nature of the sex chromosomes. Winge[1] and Jacobsen[2] have described an unequal pair of sex chromosomes which Jacobsen also identified in the somatic cells of male and female plants. Sinoto[3] found no heteromorphic pair, but described a chain of four sex chromosomes which he designated $X_1Y_1X_2Y_2$. No evidence was put forward in support of this interpretation. Ono[4], however, demonstrated in *H. lupulus* var. *cordifolius* (the wild hop of Japan) that a quadrivalent occurred in meiotic divisions in the male, but not in the female plant. More recently[5] he has described the occurrence, in a number of male varieties, of five different sex chromosome types, one of which is a homomorphic pair, two are heteromorphic pairs with different length ratios, and two are complexes of four chromosomes, also with differing length ratios.

During the 1957 season meiosis was studied, at Wye, in six male plants, five of which were seedlings from open pollination of wild Canadian or New Mexican female plants and one (No. 15) was of unknown origin. In all six a heteromorphic pair of chromosomes could be distinguished. In four of these males a quadrivalent association was found in addition to the unequal pair. Whereas the latter was a constant feature of all divisions, the quadrivalent was not present in a number of nuclei (Fig. 1,



a *b*

Fig. 1. Meiosis in male 321. *a*, Nucleus containing a heteromorphic pair and nine bivalents; *b*, nucleus containing a heteromorphic pair, a quadrivalent and seven bivalents

Table 1

Male plant No.	No. of nuclei without quadrivalent	No. of nuclei with quadrivalent
15	13	0
OL 45	1	0
321	5	11
OR 80	6	1
RY 83	2	1
OB 79	1	2

Table 1), and in view of Jacobsen's work it seems likely that the heteromorphic pair consists of the sex chromosomes, in which case the quadrivalent must be an association of autosomes.

These observations raise doubts concerning the identity of Sinoto's and Ono's quadrivalents. The only evidence to suggest that they include the sex chromosomes is Ono's work on var. *cordifolius*. Since he has reported both quadrivalent and homotype chromosomes in wild Canadian male plants, his observation of a similar difference between male and female plants of var. *cordifolius* is not conclusive evidence that this difference is related to sex determination. Examination of meiosis in males of var. *cordifolius* by Dark (unpublished work) showed that of 66 nuclei recorded only 45 contained trivalent or quadrivalent associations, and since Ono does not indicate the number of *cordifolius* nuclei studied, this raises further doubts as to the validity of his conclusions.

Even if the quadrivalent of var. *cordifolius* is accepted as being a sex chromosome complex, it is clear from the results reported here that there is no justification for making a similar assumption about quadrivalents found in other strains, in the absence of supporting evidence.

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A Chromosome Count in *Schizaea*

The Schizaeaceae are a very ancient family of ferns, with only four very distinct genera still living. In view of their great antiquity, the cytology of these plants is of considerable interest for fern phylogeny. Manton[1] has recorded chromosome numbers in two of the four genera, namely, $n = 38$ and 76 in *Anemia*, and $n = 29$ and 30 in *Lygodium*. No information is available for *Mohria*, nor, until now, for *Schizaea*. The extreme difficulty of maintaining any of the known species of *Schizaea* in cultivation is no doubt a principal reason for this omission.

During a year's stay in New Zealand, during the tenure of a New Zealand National Research Fellowship, an opportunity arose on two occasions to obtain meiotic fixings from wild material of *Schizaea asperula* Wakefield[2] (formerly included in *S. bifida* Willdenow). The localities were Waikumete, near Auckland, and West Wanganui Inlet (West Haven), N.-W. Nelson, South Island. The same chromosome number was obtained for both localities. An example of diakinesis is illustrated in Fig. 1, showing unequivocally that $n = 77$.

It is premature to discuss the interpretation of this number except to point out that there need not be any direct relationship to the $n = 76$ found in one species of *Anemia*.

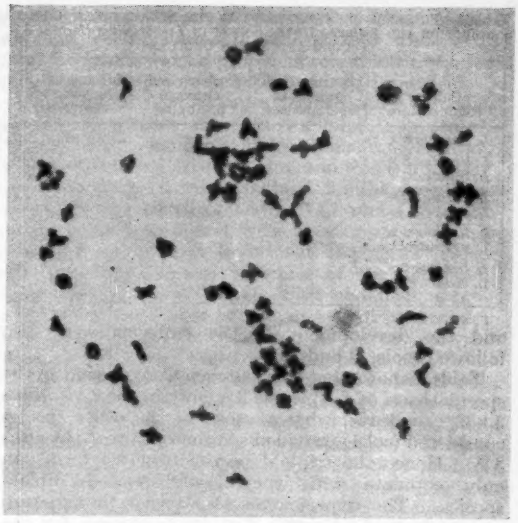

Fig. 1. Diakinesis in *Schizaea asperula* from West Wanganui Inlet, N.-W. Nelson, New Zealand, with $n = 77$. (× 750)

A more detailed description of this investigation will be published elsewhere, together with an account of work on the taxonomy and distribution of *Schizaea* in New Zealand.

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Pseudofertilization in the Genus *Lumbricillus* (Enchytraeidae)

Natural populations of the common enchytraeid worm *Lumbricillus lineatus* Müll., occurring in decaying seaweed, contain diploid ($2n = 26$) and triploid ($3n = 39$) individuals. The Enchytraeidae are normally hermaphrodite but the triploid form of *L. lineatus* reproduces parthenogenetically and is distinguishable from the diploid type by the absence of seminal vesicles. Spermatogenesis in the parthenogenetic form does not proceed beyond the spermatid stage and no mature spermatozoa are produced[1]. In spite of this, the spermathecæ of triploid worms from natural populations always contain spermatozoa. Experiments were designed to determine the origin of these spermatozoa as well as their possible role in the activation of cleavage in triploid eggs. The triploid form will be referred to as *L. lineatus* 3× and the diploid as *L. lineatus* 2×.

Cultures were set up containing either *L. lineatus* 3× alone, or together with related species of the genus *Lumbricillus* also occurring in decaying seaweed. The different combinations used are shown in Table 1 (col. 1); each culture contained at least ten worms of each species. All *L. lineatus* 3 × individuals were isolated at a sexually immature stage, before they had copulated. The cultures were examined at frequent intervals for the presence of spermatozoa in the spermathecæ of *L. lineatus* 3× (col. 2). The cocoon production of *L. lineatus* 3×

Table 1. Presence of Spermatozoa in the Spermathecæ, Cocoon Production and Embryo Development in *Lumbricillus lineatus* 3× in Pure and Mixed Cultures

Culture combinations	Spermatozoa present in spermathecæ	Cocoons laid, cleavage beginning	Cocoons hatching, cleavage completed
L. lineatus 3×	—	+	—
L. lineatus 3× *L. lineatus* 2×	+	+	+
L. lineatus 3× *L. rivalis*	—	+	—
L. lineatus 3× *L. pagenstecheri*	—	+	—
L. lineatus 3× *L. viridis*	—	+	—

and the development of the embryos were also followed (cols. 3 and 4).

Table 1 shows that spermatozoa were present in the spermathecæ of *L. lineatus* 3× only in the *L. lineatus* 3×/2× cultures, whereas none of the other species considered (col. 1) provided spermatozoa to *L. lineatus* 3×. Hence the triploid parthenogenetic form can only copulate with the closely related diploid species. The experiments also prove that spermatozoa from *L. lineatus* 2× are necessary for the successful development of the eggs of *L. lineatus* 3× (col. 4), since only in the 3×/2× cultures did the embryos of *L. lineatus* 3× hatch. In all the other combinations development was arrested before the typical dorso-ventral curvature[2] of the embryo had occurred. It has been definitely established that *L. lineatus* 3× reproduces parthenogenetically[1] and, although spermatozoa from *L. lineatus* 2× are necessary for normal cleavage of the eggs, they do not contribute chromosomes to the 3× nuclei. The exact role of the spermatozoa remains to be determined and will be dealt with in a later paper.

The observed phenomena represent a special case of pseudofertilization in which spermatozoa from a sexual diploid hermaphrodite species are necessary for the normal development of the eggs of a parthenogenetic relative. Thus although the triploid form has a parthenogenetic reproductive mechanism and is genetically isolated, it cannot exist independently of the diploid species. The term 'obligatory co-existence' gives an adequate description of this relationship. A similar case has been observed in the spider beetles *Ptinus latro* ($3n = 27$) and *P. hirtellus* ($2n = 18$)[3].

While it is recognized that the situation described presents a problem in nomenclature, the two forms will be provisionally referred to as subspecies of *L. lineatus*. Thus the name *Lumbricillus lineatus* ssp. *lineatus* is proposed for the diploid form and, because of the absence of seminal vesicles, the name *Lumbricillus lineatus* ssp. *avesiculatus* is proposed for the triploid form. The nomenclatural problem will be discussed further in a later paper.

The work is being financed by a grant from the Danish State Research Foundation (B. C.) and a University of Wales Research Fellowship (F. B. O'C.).

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[1] Christensen, B. (in course of preparation).
[2] Penners, A., *Z. wiss. Zool.*, **137**, 55 (1930).
[3] Woodroffe, G. E., and Moore, B. P., *Pest Infestation Research* (1955–56).

Records of the Group Pogonophora in the Skagerrak

Until recently, specimens of the strange deep-sea animals belonging to the group Pogonophora were known only from the Pacific. The first records were from Indonesia, and later on large samples were found by the Russians in the north-western part of the Pacific, and several species were described from this area. In 1956 I described some new finds from the eastern part of the Pacific, namely, from the Gulf of Panama, where they were taken by the *Galathea*[1]. At the same time a description appeared of a new species, *Siboglinum ekmani*, by G. Jägersten[2]. This species was found in the Skagerrak, many miles from the earlier habitats. It was taken during the Skagerrak Expedition in 1933, but not identified until recently.

In April 1957 I had the opportunity of joining the Danish Fisheries Investigations ship, s.s. *Dana*, in the same area in the Skagerrak, where *Siboglinum ekmani* had been found. At the deepest part of the Skagerrak off the south coast of Norway, 700 m. below the surface, we obtained fairly large quantities of the same species. The tubes are small, having a

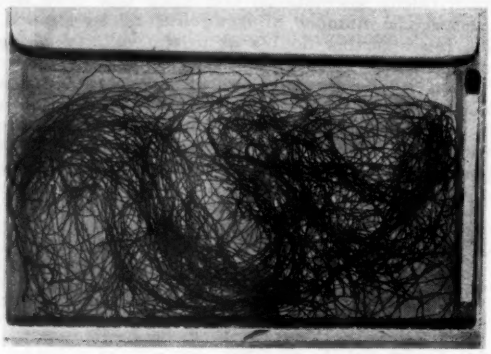

Fig. 1

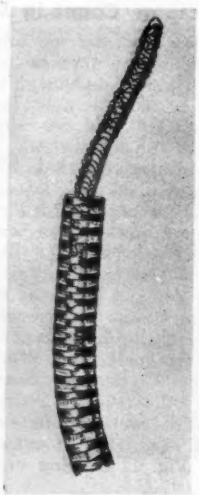

Fig. 2

diameter of 0·15 mm. and a length of about 100 mm. They are hair-like, and appear like small threads of algae or threads from the trawl (Fig. 1). But when they are seen in the microscope they are recognized at once, the structure being very characteristic (Fig. 2). The distribution of this species is probably wider than indicated by my finds. The animals seem to prefer cold water, as all the records in the world are from deep water with low temperatures. In the deep part of the Skagerrak the temperatures are about 5° C. throughout the year.

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[1] Kirkegaard, J. B., *Galathea* Report, **2**, 183 (1956).
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British Pea-crabs (*Pinnotheres*)

THE adult male and female of *Pinnotheres pisum* (Pennant) are unlike in appearance, the male being thick-shelled, with a conspicuous colour pattern, the walking legs flattened and bearing fringes of long plumose hairs, enabling it to swim. The adult female is considerably larger, thin-shelled, generally without a colour pattern and without swimming hairs.

It was formerly considered that the males of *P. pisum*, young and adult, were normally of one form, although a few so-called abnormal crabs resembling the female in consistency and lack of colour had been found[1,2]. Further work has made it clear that the male occurs in two main forms. The one which approaches the young stage-II female in appearance is seasonal in occurrence, being found mostly in the summer, June–August inclusive in south-west England, that is, during the moulting season of the male and when young crabs occur in mussels, and rarely at other times. It therefore appears that males occur in the thin-shelled form during periods of rapid growth.

Rearing of a number of males within *Mytilus*, and the moulting of others soon after their arrival in the laboratory, has shown that the male repeatedly changes from one form to the other. A curious fact is that not once did the thick-shelled male moult into the same form, one to three thin-shelled forms intervening. With few exceptions the crabs remained for a longer time in the thick-shelled than in the thin-shelled form: in the former condition they were restless, frequently leaving and re-entering their hosts, while in the latter they never did so, being unable to swim.

The thin-shelled male has a normal male abdomen, only slightly wider in relation to the width of the thorax than that of the thick-shelled male. Thick-shelled males have been found at a carapace width of 1·4–7·6 mm.; thin-shelled males 1·9–6·3 mm.

Males resembling the female in consistency and lack of colour have been recorded in *P. maculatus* by Rathbun[3] and in *P. ostreum* by Stauber[4]. In *P. pinnotheres* (L.) (= *veterum* Bosc.), in which there is no comparable sexual dimorphism, I have found only one type of male, although eight have been reared in the laboratory—one for 22 months—through as many as five moults. In this species the young adult female is capable of swimming.

The juvenile females of *P. pisum* resembling hard-shelled males have been found to pass through several growth-stages to reach the adult[1,2]. These stages have now been followed in each of four crabs with initial carapace widths of 3–4 mm., which lived for up to two years before being killed: two spawned.

All male-like females were termed stage I: this did not imply that they are the first crab stage[2]. The smallest *P. pisum*, a male, taken from *Mytilus*, had a carapace width of 1·4 mm. and this is probably not less than the third crab stage, for the megalopa has a carapace width of about 0·57 mm.[5]. Stage I females have been found with a carapace width of up to 4·9 mm., so it is evident that growth can occur with little or no widening of the abdomen. The smallest stage-II female with abdomen appreciably wider than that of the male had a carapace width of 2·1 mm. It appears that during growth, without or with only slight widening of the abdomen, the crab does not remain thick-shelled, but that one or more periods may intervene during which it is stage II in consistency, in lack of colour and of swimming hair, but with narrow abdomen. During this time the pleopods remain as little developed as in the thick-shelled stage I[2]. That these crabs are not the result of laboratory conditions is proved by their occurrence in the wild. Those few reared had empty spermathecæ.

In addition to the rearing of both *P. pisum* and *P. pinnotheres* in hosts in the laboratory, a population of *P. pisum* in the Camel Estuary, north Cornwall, was sampled approximately monthly for two years, and populations from other localities less frequently. It was found that the male *P. pisum* reaches sexual maturity at a carapace width of about 2·0 mm.: copulation is precocious, a female of 1·75 mm. carapace width being found with full spermathecæ, while the smallest ovigerous female had a carapace width of 6·5 mm.

In *P. pisum* the main spawning months in south-west England are May–August; spawning can occur three days after hatching of the previous brood, and it is probable that a crab spawns several times during the season. The main moulting season of the male is June–August, that of the female June–October.

A full account of this work and of other aspects of the biology of *P. pisum* and *P. pinnotheres* will be published elsewhere.

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[1] Orton, J. H., *Nature*, **106**, 533 (1920–21).
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The Cromer Forest Bed: Preglacial or Interglacial?

Now that the detailed palæobotanical account of the interglacial deposits at Bobbitshole, Ipswich, by Dr. R. G. West[1], of the University Sub-department of Quaternary Research, Cambridge, has appeared we are better able to appreciate the magnitude of our debt to him and to their finder, Mr. H. E. P. Spencer, of the Ipswich Museum. Correlation of East Anglian and Continental late Pleistocene events has been thereby substantially aided, but in the concluding section of

the paper a statement re-appears about the correlation of an older phase which is difficult to reconcile with our records of East Anglian stratigraphy. The statement is that, in the opinion of the well-known authority, Prof. P. Woldstedt[2], the palynology of the Cromer Forest Bed series shows that it "was formed in the oldest (Cromerian) interglacial period in East Anglia". Dr. West has, apparently independently, reached the same conclusion. It therefore becomes desirable to direct attention to some of the geological difficulties that arise from this interpretation.

The occurrence of an interglacial phase implies that of a preceding glaciation, but no moraines or till belonging to such are known in East Anglia before the Cromer Forest Bed was formed. Admittedly, all traces may have been removed in the course of a subsequent glaciation, or completely covered and not revealed by borings and excavations since. In that event, we are driven to utilize the evidence from neighbouring areas, for example, northern Europe. Before referring to the latter, however, I may note that the East Anglian shelly sands and gravels, known as Crag, which are in the main (if not wholly) older than the Cromer Forest Bed, furnish no sound evidence of climatic change other than a gradual cooling (shown by the Mollusca) and the possible transport of erratics by icebergs from the north. The implications of a Crag glaciation were reviewed in detail some years ago[3], when efforts were made to resolve certain difficulties that had arisen in the linking up of the industries of early man with well-established glacial and interglacial events; but the assumption of an early Crag glaciation seemed to increase rather than lessen the difficulties.

The succession that has served us reasonably well as a standard in the east of England for many years past is set out in Table 1 (in which I have retained the older nomenclature as well as the newer terms because it remains more appropriate in several respects). The various early human industries can be fitted into the scheme (allowing for time occupied in migration) without excessive strain.

Table 1

Hunstanton Boulder Clay (Newer Drift) = Warthe, ? Weichsel = Würm
Interglacial (Bobbitshole, etc.) = Eemian in part
Upper Chalky Drift (Gipping Boulder Clay) = Saale = Riss
Interglacial (Hoxne, etc.) = Elster/Saale = Mindel/Riss
Chalky-Jurassic Boulder Clay (Lowestoft Boulder Clay) = Elster = Mindel
Interglacial ("Middle" glacial, Corton Beds, etc.) = ? Günz/Mindel
North Sea Drift (Norwich Brickearth, Cromer Tills ?) = ? Donau, ? Günz 1, ? Günz 2
Cromer Forest Bed series
Pleistocene shelly sands (Crags)

The succession recorded in the lower half of the table is based on the evidence from inland and coastal exposures in northern and eastern Norfolk. At Corton, north of Lowestoft, for example, a peaty bed at beach-level, tentatively referred by Clement Reid to the Cromer Forest Bed, is seen to be succeeded by the Norwich brick-earth, then by the sands and gravels termed by D. F. W. Baden-Powell the Corton Beds (in which, in the nearby Flegg Hundred, S. V. Wood, jun., found molluscan assemblages of mixed character), and finally by the Chalky-Jurassic Boulder Clay. On the northern coast of Norfolk the Cromer Forest Bed visibly underlies the Cromer Till, which in turn underlies sands containing a shelly fauna and identified by Baden-Powell with his Corton Beds. The interglacial phase here represented was marked by widespread weathering and erosion of the Norwich brick-earth and the overlying sands and gravels, the major valley-systems of the region being then brought into existence.

In passing, I may note that if the Cromer Tills come to be regarded as a facies of, not the North Sea Drift, but the Chalky-Jurassic Boulder Clay, the Cromer Forest Bed may prove to belong to this interglacial interval. In that event, however, the peaty bed at Corton cannot be the Cromer Forest Bed. Further investigations of this peaty bed throughout eastern Norfolk are thus highly desirable. Although we possess much information about the fossil contents of the Cromer Forest Bed at its type locality, we know strikingly little about its areal distribution or about the extent in space and time of the unconformity that underlies it.

Evidence from the Continent in support of the view that the Cromer Forest Bed belongs to the oldest interglacial is far from good. Geologists have hitherto been unable to agree that any trace of the earliest (Günz) glaciation of the Alps occurs in the area of northern Europe extending from the Netherlands to the U.S.S.R. While some authorities still doubt the existence of the Günz in the Alpine area itself, others see in the pre-Mindel moraines and other glacial deposits of the peripheral area the relics of separate glaciations which have been termed[4] the Donau, Günz 1 and Günz 2. Early interglacial or interstadial deposits have in places yielded pollen-bearing beds, but the stratigraphical relationships are not sufficiently precise to enable geological correlation to be established. Baden-Powell's comparison[5] of the shelly faunas of the Mediterranean Pleistocene marine stages (terraces, etc.) with those in East Anglia favours the view that the oldest interglacial follows rather than precedes the North Sea Drift glaciation. With considerable skill he has diagnosed the Corton Beds fauna as the climatic equivalent of the Tyrrhenian stage of the Mediterranean under a modified Pleistocene isothermal distribution. This phase followed the first cold stage in that area—the Sicilian—which he would correlate with the earliest glaciation of northern Europe.

Until the figures for absolute age obtained by tests for radioactivity become available (and they are slow to accumulate), we rely for correlation on the evidence provided by fossil groups such as the Mammalia, Mollusca and plants, among others; also, in order that the risk of homotaxial relationships being mistaken for contemporaneity may be reduced to a minimum, we hope the lines of evidence will converge. The classification of the East Anglian Pleistocene set out above is doubtless over-simplified by the omission of stadia and interstadia, but there seems little advantage in altering the status (for example, glaciation into stadial ice-advance, or *vice versa*) of our well-individualized events, even for the time being. The alternative is to await new evidence. Until some of the difficulties outlined in the foregoing have been met, it would appear premature to assign the Cromer Forest Bed to the oldest interglacial period in East Anglia.

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[1] *Phil. Trans. Roy. Soc.*, B, **241**, 1 (1957).
[2] *Nature*, **165**, 1002 (1950).
[3] *Proc. Geol. Assoc. Lond.*, **42**, 87 (1931). Rep. Brit. Assoc. Meeting York, 1932, 63. *Proc. Prehistoric Soc. Lond.*, No. 6, 149 (1936).
[4] See, for example, Zeuner, F. E., *Nature*, **173**, 1178 (1954).
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FORTHCOMING EVENTS

Monday, April 14

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Mr. G. W. Kirkland, M.B.E.: "Pre-stressed Concrete". (First of three Cantor Lectures. Further Lectures on April 21 and 28.)

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion Meeting on "Personality". Chairman: Prof. C. A. Mace. Speakers: Prof. Marc Klein, Dr. W. Mays and Dr. J. D. Sutherland.

Tuesday, April 15

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND UTILIZATION SECTIONS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Prof. E. Bradshaw, Mr. M. Wagstaff and Mr. F. Cooke: "A Train Performance Computer"; Mr. J. F. Meredith and Mr. E. A. Freeman: "The Stimulation of Distributed-Parameter Systems, with particular reference to Process Control Problems"; Dr. J. L. Douce and Dr. J. C. West: "A Magnetic-Drum Store for Analogue Computing".

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. E. G. Walker: "Factors in the Design of Airborne Doppler Navigation Equipment".

Tuesday, April 15—Thursday, April 17

SOCIETY OF CHEMICAL INDUSTRY, PLASTICS AND POLYMER GROUP (in the William Beveridge Hall, Senate House, University of London, London, W.C.1)—Silver Jubilee Symposium on "The Physical Properties of Polymers".

Wednesday, April 16

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. W. E. Tremlett: "The Structure of the Lower Palæozoic Rocks of the Arklow District (Ireland)".

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.15 p.m.—Discussion on "Some Problems in the Measurement of Price Changes, with special reference to the Cost of Living" opened by Dr. S. J. Prais.

INSTITUTION OF ELECTRICAL ENGINEERS, SUPPLY SECTION (joint meeting with the BRITISH NUCLEAR ENERGY CONFERENCE, at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. K. L. Stretch: "Operational Experience—Calder Hall".

SOCIETY FOR ANALYTICAL CHEMISTRY, BIOLOGICAL METHODS GROUP (at "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m.—Discussion on "The Mathematics of Sterility Testing", introduced by Mr. D. Maxwell Bryce.

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Annual General Meeting. Dr. W. H. J. Vernon: "Corrosion Research and its Industrial Background" (Spring Lecture).

Thursday, April 17

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. P. G. Safeman and Sir Geoffrey Taylor, F.R.S.: "The Penetration of a Fluid into a Porous Medium or a Hele-Shaw Cell containing a More Viscous Liquid"; Mr. C. Kemball and Mr. C. T. H. Stoddart: "The Catalytic Hydrogen Reduction and Deuterium Exchange of *cyclo*pentanone on Evaporated Metallic Films and some Observation s on *cyclo*hexanone".

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. E. O. Lilge, Mr. T. E. Fregren and Mr. G. R. Purdy: "Apparent Viscosities of Heavy Media and the Driessen Cone"; Mr. H. H. Fraser: "Scientific Management Principles Applied to West African Mining".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. J. G. Clunie: "Meromorphic Schlicht Functions".

INSTITUTION OF MECHANICAL ENGINEERS, APPLIED MECHANICS GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m. Discussion on "Training in Engineering Design".

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. R. J. Schaffer: "The Preservation of Building Stone".

ROYAL PHOTOGRAPHIC SOCIETY (at 16 Princes Gate, London, S.W.7), at 7 p.m.—Mr. J. B. Collins: "Some Applications of Photography to Lighting Research".

Thursday, April 17—Friday, April 18

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (in the Hall of the Royal Geographical Society, Kensington Gore, London, S.W.7), at 10 a.m. daily—Conference on "Science in Schools".

Friday, April 18

INSTITUTE OF PHYSICS, NON-DESTRUCTIVE TESTING GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Meeting on "High Speed Radiography". Mr. R. F. Thumwood: "Tubes and Mechanisms"; Mr. B. Meakin: "Circuits and Evaluation".

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Annual General Meeting.

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. E. G. E. Hawkins: "Organic Peroxides and their Industrial Uses".

Friday, April 18—Saturday, April 19

BIOCHEMICAL SOCIETY (at University College, Gower Street, London, W.C.1), at 10.45 a.m. on Friday and 10.30 a.m. on Saturday—Annual General Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

RESEARCH WORKER IN RUMEN BIOCHEMISTRY (Scientific Officer or Senior Scientific Officer grade)—The Secretary, Institute of Animal Physiology, Agricultural Research Council, Babraham, Cambridge (April 17).

LECTURER IN GEOLOGY; a LECTURER IN MATHEMATICS; a SENIOR LECTURER or LECTURER and an ASSISTANT IN NATURAL PHILOSOPHY; a SENIOR LECTURER or LECTURER and an ASSISTANT IN EXPERIMENTAL PHYSICS; and a LECTURER and an ASSISTANT IN THEORETICAL PHYSICS—The Secretary, The University, Aberdeen (April 18).

LECTURER (with a good honours degree in botany, a special interest in mycology and able to teach botany to degree standard and also industrial mycology) IN BOTANY—The Principal, Wigan and District Mining and Technical College, Wigan (April 18).

ASSISTANT LECTURER (science graduate or medically qualified) IN PHARMACOLOGY in the Faculty of Medicine—The Registrar, The University, Manchester 13 (April 19).

BIOCHEMIST (Basic grade), to work mainly on problems of calcium and phosphorus metabolism in the Metabolic Ward Laboratories—The Administrator and Secretary, University College Hospital, Gower Street, London, W.C.1 (April 19).

SCIENTIFIC OFFICER (with a good honours degree in zoology, some research experience in invertebrate physiology, and an interest in ecology) at Merlewood Research Station, Grange-over-Sands, Lancashire, to join a team studying fauna and woodland soils—The Nature Conservancy (E), 19 Belgrave Square, London, S.W.1 (April 21).

ASSISTANT LECTURER, Grade B (with good academic qualifications and special experience in physical chemistry), IN CHEMISTRY—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (April 25).

ASSISTANT LECTURER (man or woman) IN BOTANY—The Principal, Royal Holloway College, Englefield Green, Surrey (April 25).

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF ZOOLOGY—The Registrar, The University, Liverpool (April 26).

FELLOW IN THE DEPARTMENT OF GEOPHYSICS, Research School of Physical Sciences, Australian National University, Canberra, to assist in the Department's programme of work on rock magnetism—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 30).

LECTURER (medical graduate, with lecturing experience and practical experience in virology and bacteriology) IN BACTERIOLOGY—The Registrar, The University, Bristol (April 30).

TURNER AND NEWALL RESEARCH FELLOWS IN ENGINEERING, INORGANIC CHEMISTRY, PHYSICS and allied subjects—The Registrar, The University, Manchester (April 30).

ASSISTANT LECTURER or LECTURER IN PHYSICS—The Secretary, The University, Exeter (May 3).

ASSISTANT LECTURER or LECTURER (specially qualified in plant biochemistry and/or cell physiology) IN THE DEPARTMENT OF BOTANY—The Registrar, University College, Singleton Park, Swansea (May 3).

LECTURER IN THE DEPARTMENT OF METALLURGY—The Registrar, The University, Liverpool (May 3).

RESEARCH DEMONSTRATOR IN BOTANY—The Registrar, University College, Singleton Park, Swansea (May 3).

RESEARCH FELLOW IN THE DEPARTMENT OF MATHEMATICAL PHYSICS—The Registrar, The University, Birmingham 15 (May 5).

READER IN EXPERIMENTAL PHYSICS at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 7).

READER IN STATISTICS at the London School of Economics and Political Science—The Academic Registrar, University of London Senate House, London, W.C.1 (May 9).

LECTURER IN BIOCHEMISTRY; an ASSISTANT IN BIOCHEMISTRY; and an ASSISTANT IN LOGIC AND METAPHYSICS AND MORAL PHILOSOPHY in St. Salvator's College—Joint Clerk to the University Court, College Gate, St. Andrews (May 10).

LECTURER IN MICROBIOLOGY IN THE DEPARTMENT OF BREWING AND APPLIED BIOCHEMISTRY—The Principal, Heriot-Watt College, Edinburgh (May 15).

RESEARCH STUDENTS or ASSISTANTS FOR WORK IN THE PHYSICAL CHEMISTRY DEPARTMENT on the mechanism of reactions of biological interest—The Secretary of University Court, The University, Glasgow (May 15).

SENIOR LECTURER IN ZOOLOGY at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 15).

SENIOR RESEARCH FELLOW (preferably theoretical physicist) IN PHYSICS at the University of New England, Australia, to undertake a programme of experimental or theoretical research, preferably but not necessarily on the field of ionization and discharge physics or of solid

state physics—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, May 26).

Chair of Geography in the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 30).

Chair of Pharmaceutics in the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 31).

Lecturer in Psychology at Canberra University College, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, May 31).

Scientific Assistant (preferably with a Ph.D. in biochemistry and some experience with proteins) in the Department of Pathology, for research work on intrinsic factor—The Registrar, King's College (University of Durham), Newcastle-upon-Tyne.

Senior Lecturer or Lecturer in Physics at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

Senior Lecturer (with at least three years experience of teaching to degree standard and also preferably a higher degree) in Zoology—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

REPORTS and other PUBLICATIONS

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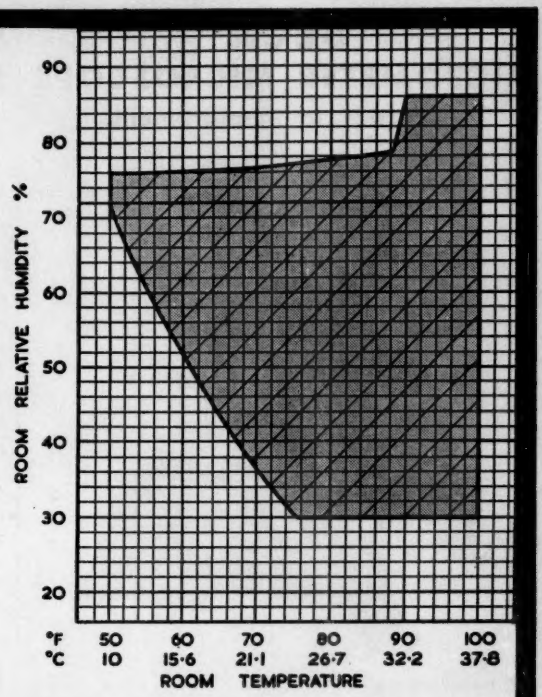

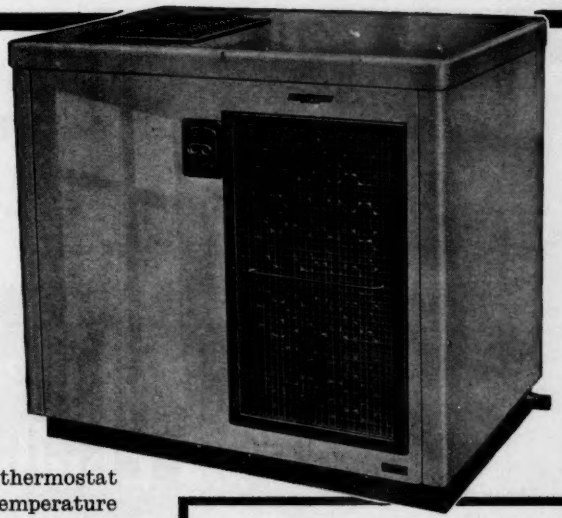

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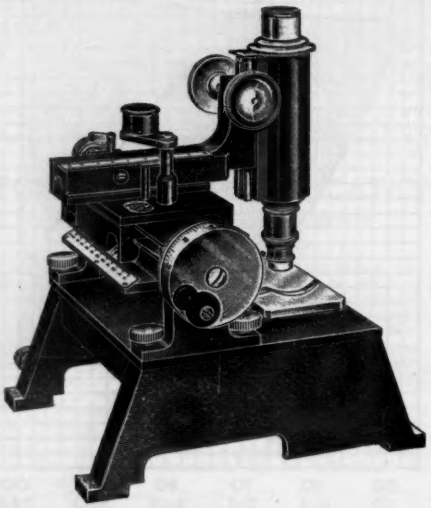

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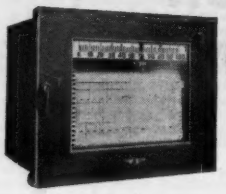

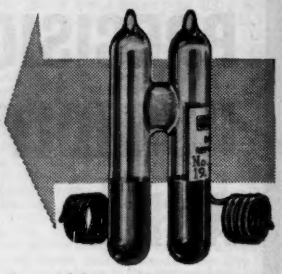

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